OCCIDENTAL OF ELK HILLS, INC.

TULARE AQUIFER EXEMPTION DOCUMENT

ELK HILLS FIELD

September 14, 2014

Prepared by:

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Bakersfield, California

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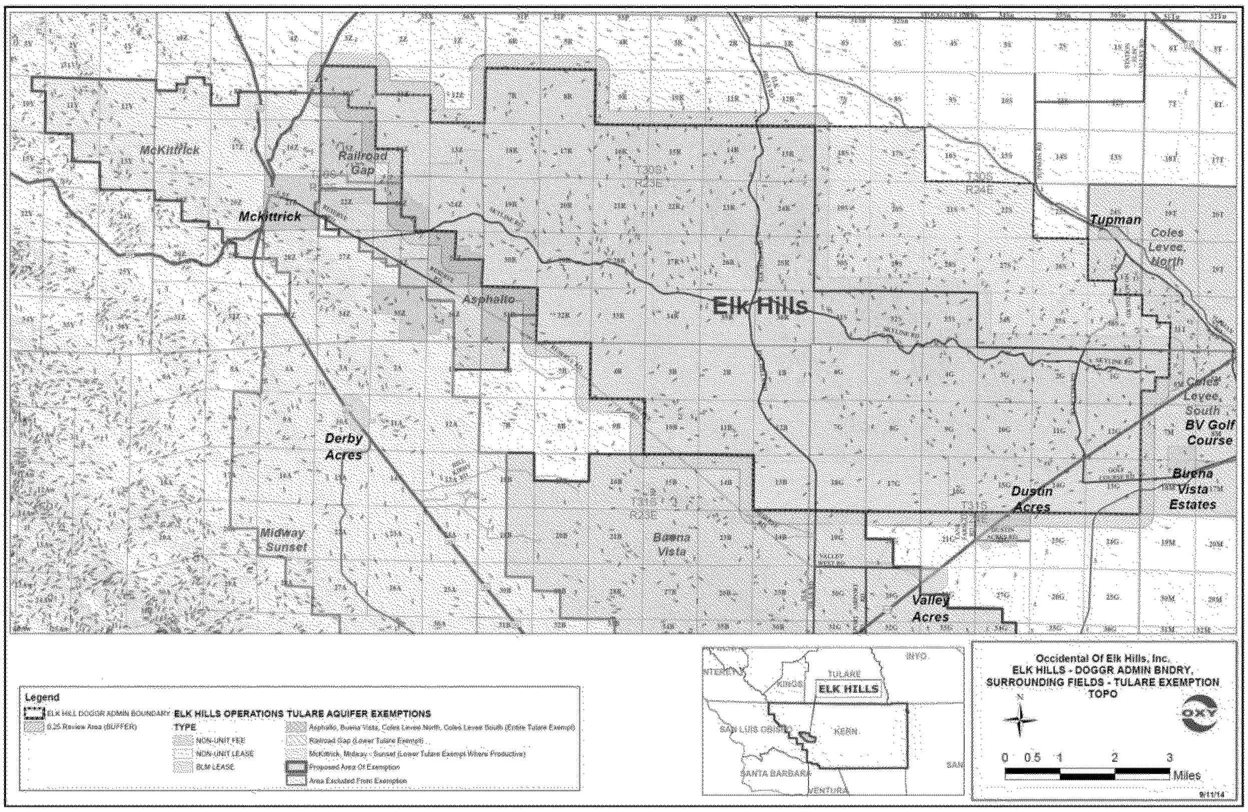
EXECUTIVE SUMMARY

As stated in Section 3106 of Article 2 in Chapter 1 of Division 3 of the State of California Public Resources Code, the Supervisor of the Division of Oil, Gas and Geothermal Resources (DOGGR) is directed to administer the DOGGR so as to encourage the wise development of oil and gas resources to best meet oil and gas needs in this state. Injection of produced water is a necessary part of the development of these resources. To allow for continued oilfield development of the Elk Hills field, Occidental of Elk Hills, Inc., (OEHI) is providing documentation for the aquifer exemption of the Tulare Formation. The project area, referred to in this document as the Elk Hills Tulare aquifer exemption area, is shown in light green area on the following map. The Tulare aquifer exemption is for the purpose of continuing Class II[1] Underground Injection Control (UIC) operations in the Elk Hills field The Tulare aquifer exemption interval includes all of the saturated upper Tulare zone and both the unsaturated and saturated lower Tulare zone below the Amnicola claystone confining zone. The Tulare Formation is already an exempt aquifer in all or portions of the surrounding fields, as shown on the following map.



Map of the Elk Hills Tulare Aquifer Exemption Area and Tulare Exemptions in Nearby Fields

[1] As defined on the DOGGR home page, Class II UIC wells inject fluids associated with oil and natural gas production operations. Most of the injected fluid is brine that is produced when oil and gas are extracted from the earth. Class II UIC wells also inject fluids for enhanced oil recovery or storage of liquid hydrocarbons.

Based on 40 Code of Federal Regulations (CFR) §146.4, the Tulare aquifer exemption is justified on the following grounds (checked if applicable to OEHI):

√ a) It does not currently serve as a source of drinking water, and

√ b) It cannot now and will not in the future serve as a source of drinking water because:

√ (1) It is hydrocarbon-producing or can be demonstrated by the permit applicant as part of a permit application for a Class II operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

__ (2) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

√ (3) It is so contaminated that it would be economical ly or technologically impractical to render that water fit for human consumption; or

___ (4) It is located over a Class III well mining area subject to subsidence or catastrophic collapse; or

√ c) The total dissolved solids (TDS) content of the groundwater is more than 3,000 and less than 10,000 milligra ms/liter (mg/l) and it is not reasonably expected to supply a public water system.

The Tulare aquifer exemption area originally consisted of 72.4 square miles, or about 99% of the Elk Hills field. After meetings and discussions between OEHI, San Joaquin Energy Consultants (SJEC), and representatives from the West Kern Water District (WKWD), the Kern County Water Agency (KCWA), and the Kern Water Bank Authority (KWBA), the northeastern flank area of the Elk H ills field was excluded from the Tulare aquifer exemption area. The Tulare aquifer exemption area currently consists of about 59.0 square miles, or about 80% of the Elk Hills field.

The following reasons support an aquifer exemption of the Tulare Formation within the area of review, which is defined as the 59.0-square mile Elk Hills Tulare aquifer exemption area plus a buffer zone with a fixed distance of 0.25 mile.

1. The WKWD, the local waterprovider in the area, has declared that the Tulare Formation within the Elk Hills aquifer exemption area does not currently serve as a source of drinking water and will not reasonably be expected to supply a public water system.
2. The Tulare Formation in the Elk Hills field was referred to and treated as an exempt aquifer by the U. S. Environmental Protect ion Agency (EPA) when it authorized Class I[2] non-hazardous injection in two Tulare disposal wells for Elk Hills Power, LLC, under UIC Permit #CA200002. In addressing public comments received during the review process, the EPA wrote that it "… had made the determination that the Tulare Formation within the Area of

[2] According to the DOGGR website, Class I UIC injection wells inject hazardous and non -hazardous wastes below the lowermost underground source of drinking water (USDW). Injection occurs into deep, isolated rock formations that are separated from the lowermost USDW by layers of impermeable clay and rock.

Review is an exempt aquifer." The area of review for the Elk Hills Power UIC permit was in section 18, T31S/R24E[3], which has Tulare groundwater that is comparable in its poor quality to other areas of the Elk Hills field. The original UIC permit, dated February 21, 2001, was later modified to authorize two additional Tulare injection wells on June 3, 2004. Nearly 35 million barrels (bbls) of industrial, nonhazardous fluids produced during the operation of the Elk Hills Power Plant were injected into the Tulare Formation in the 18G area.

3. The Tulare Formation has been used since July 1981 for injection of produced water. Although this was after the DOGGR's submittal of its 1981 Primacy Application[4], it was well before the EPA granted the DOGGR primacy on September 29, 1982. In this 14-month interim, the Tulare Formation in the Elk Hills field was not part of any amendment to the Primacy Application. As a result, it was omitted as an exempt aquifer based on being a non-hydrocarbon producing zone used for wastewater disposal.

4. A large portion of the Tulare Formation within the Elk Hills field has been regularly described and treated by the DOGGR as an exempt aquifer for Class II UIC injection. Two Class II injection projects and several project expansions were approved by the DOGGR. More than 130 Tulare wastewater disposal wells have been permitted since July 1981, through which more than one billion bbls of Class II formation water have been disposed. Past and current Class II injection operations in the project area have contributed to groundwater degradation in the Tulare aquifer exemption area. Naturally saline produced water disposed in the Tulare Formation has TDS concentrations in excess of 28,000 mg/l as well as high concentrations of iron, chloride, and boron.

5. The Tulare Formation in the Elk Hills field has produced oil since 1975 and was documented as a March 1975 discovery in the DOGGR's 1998 version of *California Oil and Gas Fields*. Although the March 1975 discovery pre-dates the DOGGR's 1981 Primacy Application, the Tulare Formation in the Elk Hills field was not included as an exempt aquifer based on hydrocarbon production when primacy was granted on September 29, 1982.

6. The Tulare aquifer exemption area is adjacent to oil fields in which all or part of this formation has been exempted based on being used for disposal of naturally saline Class II wastewater and/or commercial oil and gas production. The Tulare Formation is stratigraphically continuous throughout the proposed aquifer exemption area and with the adjacent fields in which it already is an exempt aquifer.

7. The Tulare Formation in the Elk Hills field locally contains groundwater that has TDS concentrations greater than 10,000 mg/l in intervals near its base and does not meet the definition of a protected USDW in those intervals.

8. Tulare groundwater in the Elk Hills field contains a lead concentration that exceeds the primary maximum contaminant level (MCL) for drinking water and concentrations of TDS, chloride, and sulfate that exceed secondary MCLs. Boron, strontium, and sodium concentrations in Tulare groundwater are significantly in excess of regulatory thresholds for human health,

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[3] T31S/R24E = G.

[4] 1981 Primacy Application refers to *Application for Primacy in the Regulation of Class II Injection Wells under Section 1425 of the Safe Water Drinking Water Act* submitted to the EPA in April 1981.

agricultural uses, and/or livestock watering. Iron concentrations are variable but also can exceed secondary MCLs and regulatory thresholds for human health, respectively.

9. The Tulare Formation in the Elk Hills field had producible quantities of oil in the area of section 30, T30S/R23E[5]. It currently has commercial gas production in the area of section 31, T30S/R24E[6], and a shut-in gas well in the 28R area. In addition, Tulare oil and gas shows occur in a number of wells throughout the field. However, the Tulare Formation historically has not been the main target of exploration and development in the Elk Hills field and therefore has relatively little well data to evaluate its commercial potential. Although its current and past production history and oil and gas shows are good indicators, commercial oil and gas potential in the Tulare will depend on evaluation of this zone during future drilling.

10. The designated beneficial uses of groundwater within the area of review are municipal and domestic supply (MUN)[7], agricultural supply (AGR)[8], and industrial service supply (IND)[9]. However, the poor quality of Tulare groundwater renders it unusable for domestic or agricultural usage because: its lead concentration exceeds the California Title 22 primary MCL for drinking water; TDS, chloride, and sulfate concentrations exceed secondary drinking water MCLs; and boron, strontium, and sodium concentrations exceed regulatory thresholds for human health, agricultural uses, and/or livestock watering. Iron is variable but also can exceed the secondary MCLs for drinking water and regulatory thresholds for human health, respectively. The occurrence of petroleum in local areas of the Elk Hills field also contributes to Tulare groundwater degradation and adversely affects its designated beneficial uses.

11. The Tulare aquifer exemption area is located in a remote and sparsely populated area of Kern County. Land in the Tulare aquifer exemption area is zoned as agricultural but only a small portion of section 13G in the Elk Hills field is irrigated as farmland. The primary use of land within the area of review is related to oilfield operations.

12. Based on water well database searches, well records review, and site reconnaissance, there are no known water wells located within the area of review.

13. Domestic, agricultural, and industrial water in the Tulare aquifer exemption area is supplied primarily by water from the State Water Project (SWP) via the California Aqueduct and two WKWD well fields. According to its 1997 *Groundwater Management Plan*, the WKWD believed that: 1) its water supplies were adequate to meet peak daily demands and future needs; and 2) despite potential shortages in SWP deliveries, it did not need to pursue additional sources of water.

14. An evaluation of the economic feasibility of treating Tulare groundwater in the McKittrick area for use as drinking water concluded that treating this groundwater would cost about 12 to

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[5] T30S/R23E = R.

[6] T30S/R24E = S.

[7] MUN uses of water: Community, military, or individual water supply systems including, but not limited to, drinking water supply.

[8] AGR uses of water: Farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.

[9] IND uses of water: Industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection and oil well repressurization.

70 times the current potable water treatment cost per household. The EPA criteria for designating Tulare groundwater as Class III[10] based on economic infeasibility, were met because the total annual system cost per area household to treat Tulare groundwater: a) exceeded 0.4% of the median annual household income; b) was more than 100% of the current water rate; and c) was greater than the ninetieth percentile economic untreatability threshold of $379.14 per household. Concentrations of TDS, chloride, sulfate, boron, and sodium in McKittrick area groundwater are comparable to Tulare groundwater in the Elk Hills field. However, Elk Hills Tulare groundwater also has higher concentrations of lead and hydrocarbons, the removal of which would increase treatment costs and, consequently, increase the economic infeasibility to treat it for use as drinking water.

15. The Tulare groundwater in the Elk Hills field has low resource value or beneficial uses except for its use in Class I non-hazardous and Class II UIC injection operations.

16. Hydraulic fracturing will not be required as part of development of the Tulare Formation in the Elk Hills field.

[10] Class III groundwater is defined as groundwater that is not a source of drinking water because it consists of groundwater that is saline or otherwise contaminated beyond levels that would permit its use as drinking water or for other beneficial purposes. Class III groundwater can: 1) have a TDS concentration in excess of 10,000 mg/l; 2) be so contaminated by naturally occurring conditions or broad-scale human activity (unrelated to a specific activity) that it cannot be cleaned up using treatment methods reasonably employed in public water supply systems; or 3) have insufficient yield to meet the minimum needs of an average household. Both a reference technology test, which compares the treatment needed for the contaminated groundwater to relevant treatment technologies for public water treatment, and an economic untreatability test, which determines whether treatment costs would be economically feasible for a hypothetical user population, are used to classify groundwater as Class III (EPA, 1988).

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A. OPERATOR INFORMATION

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Tupman, California 93276-1001
Phone: (661) 763-6000

B. EXEMPTION AREA DESCRIPTION

The Tulare aquifer exemption area is located on the western side of the southern San Joaquin Valley (Exhibit 1). The Elk Hills Tulare aquifer exemption area originally was 72.4 square miles and included about 99% of the Elk Hills field lying within the DOGGR's administrative field limits. After meetings and discussions between OEHI, SJEC, and representatives of the WKWD, the KCWA,and the KWBA, thenortheastern flank of the Elk Hills field was excluded from the Tulare aquifer exemption area, reducing thetotal area to about 80% of the field. The Tulare aquifer exemption area currently consists of about 59.0 square miles, or 37,780.2 acres, and includes nearly all of the Elk Hills field lying within the DOGGR's administrative limits, with the exception of the following areas (Exhibit 2):

<u>Township 30 South, Range 24 East (= S)</u>

All of section 17
All of section 18
All of section 19
All of section 20
All of section 21
All of section 22
South 1/2 of the Southwest 1/4 of Section 25
All of section 26
All of section 27
All of section 28
All of section 29
All of section 30
All of section 34
All of section 35
All of section 36

Township 30 South, Range 25 East (= T)

The following portions of Section 31:

South 1/2 of Southwest 1/4 of Northwest 1/4

Southwest 1/4

The area of review for this document consists of the 59.0-square mile Tulare aquifer exemption area plus a buffer zone with a fixed distance of 0.25 mile, as shown on Exhibit 1 and Exhibit 2.

The Tulare aquifer exemption interval consists of all of the saturated upper Tulare zone and both the unsaturated and saturated lower Tulare zone below the Amnicola claystone confining zone.

The following is a description of the Tulare aquifer exemption area:

Township 30 South, Range 22 East (= Z)

The following portions of Section 10:

North 1/2

North 1/2 of Southeast 1/4

South 1/2 of Section 11:

All of Section 13

The following portions of Section 14:

North 1/2

Southeast 1/4

The following portions of Section 23:

Northeast 1/4

North 1/2 of Southeast 1/4

Southeast 1/4 of Southeast 1/4

All of Section 24

Northeast 1/4 of Section 25

Township 30 South, Range 23 East (= R)

All of Section 7

All of Section 8

All of Section 13

All of Section 14

All of Section 15

All of Section 16

All of Section 17

All of Section 18

All of Section 19

All of Section 20

All of Section 21

All of Section 22

All of Section 23
All of Section 24
All of Section 25
All of Section 26
All of Section 27
All of Section 28
All of Section 29
All of Section 30
All of Section 32
All of Section 33
All of Section 34
All of Section 35
All of Section 36

<u>Township 30 South, Range 24 East (= S)</u>
All of Section 31
All of Section 32
All of Section 33

<u>Township 31 South, Range 23 East (= B)</u>
All of Section 1
All of Section 2
All of Section 3
All of Section 4
All of Section 10
All of Section 11
All of Section 12
All of Section 13

<u>Township 31 South, Range 24 East (= G)</u>
All of Section 1
All of Section 2
All of Section 3
All of Section 4
All of Section 5
All of Section 6
All of Section 7
All of Section 8
All of Section 9
All of Section 10
All of Section 11
All of Section 12
All of Section 13

All of Section 14
All of Section 15
All of Section 16
All of Section 17
All of Section 18

Township 31 South, Range 25 East (= M)
The following portions of Section 6:
Northwest 1/4
Northwest 1/4 of Southwest 1/4

C. DECLARATION FROM LOCAL WATER AGENCY

The WKWD has the authority to provide water to municipal and industrial users within the area of review. It has provided the DOGGR with a letter stating that the Tulare Formation within the Elk Hills aquifer exemption area does not currently serve as a source of drinking water and would not reasonably be expected to supply a public water system (Exhibit 3).

D. JUSTIFICATION FOR AQUIFER EXEMPTION

An exempt aquifer is an aquifer or portion of an aquifer that meets specific criteria, for which protection under the Safe Water Drinking Act (SDWA) has been waived by the UIC Program under 40 CFR §146.4. Based on 40 CFR §146.4, OEHI is proposing a Tulare aquifer exemption within the area of review based on the following reasons (checked if applicable to OEHI).

(√) 1. It does not currently serve as a source of drinking water, and

(√) 2. It cannot now and will not in the future serve as a source of drinking water because:

(√) (a) If it is mineral, hydrocarbon, or geothermal energy producing, or it can be demonstrated by a permit applicant for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.

(_) (b) It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;

(√) (c) It is so contaminated that it would be economical or technologically impractical to render that water fit for human consumption; or

(__) (d) It is located over a Class III well mining area subject to subsi dence or catastrophic collapse; or

(√) 3. The TDS content of the groundwater is more than 3,000 and less than 10,000 mg/l and it is not reasonably expected to supply a public water system.

The following sections provide documentation to support the Elk Hills Tulare aquifer exemption.

E. EXISTING AQUIFER EXEMPTIONS WITHIN THE AREA OF REVIEW

1. History of the Aquifer Exemption Process

In April 1981, the DOGGR applied to the EPA for primacy in the regulation of Class II UIC injection wells under Section 1425 of the SWDA. Non-hydrocarbon producing zones being used for injection of produced water were identified as exempt aquifers in the Primacy Application. The hydrocarbon-producing zones that the DOGGR identified as exempt aquifers in the 1981 Primacy Application were the productive zones shown as shaded areas on maps and cross-sections in the 1973 version of *California Oil and Gas Fields* (California Department of Conservation, 1973). For petroleum discoveries after 1973, all new productive areas should have been included in the Primacy Application. The DOGGR was granted primacy and aquifer exemptions were approved in the DOGGR-EPA Memorandum of Agreement (MOA), dated September 19, 1982. The list of exempt aquifers was included in a letter dated May 17, 1985, from Mr. Frank M. Covington of the EPA to Mr. Tom Cornwell of Western Oil and Gas Association (Exhibit 4). Zones with TDS concentrations exceeding 10,000 mg/l do not meet the definition of a protected USDW and are automatically exempt aquifers (Exhibit 4).

Numerous zones within and adjacent to the Tulare aquifer exemption area in the Elk Hills field are aquifers that already have been exempted based on: 1) being economically infeasible to treat for use as drinking water under 40 CFR §146.4; 2) being a non-hydrocarbon-producing zone used for Class II injection at the time of the 1981 Primacy Application; 3) the occurrence of commercial hydrocarbons; and 4) not being protected USDWs being they contain TDS concentrations in excess of 10,000 mg/l. The Tulare Formation within the entire field administrative limits of the Asphalto field is an exempt aquifer based on being economically infeasible to treat for drinking water (Exhibit 2; Exhibit 5; Exhibit 7). Within the entire administrative limits of the Buena Vista field, the Tulare was exempted because it was a non-hydrocarbon producing zone being used for wastewater disposal (Exhibit 2; Exhibit 5; Exhibit 8). In the Railroad Gap field, only the Amnicola zone in the lower Tulare Formation has an aquifer exemption based on commercial hydrocarbon production[11] (Exhibit 9). In the northern Midway-Sunset and the McKittrick fields, the Tulare Formation also has an aquifer exemption based on commercial oil production, shown as shaded areas on some of the maps and cross-sections in Exhibit 10 and Exhibit 11. The North Coles Levee and South Coles Levee fields have

[11] The Amnicola zone is exempt only within the productive area of the Railroad Gap field, but this area is not shown on Exhibit 9.

Tulare aquifer exemptions based on TDS concentrations in excess of 10,000 mg/l (Exhibit 4; Exhibit 12; Exhibit 13).

Aquifer exemptions in the fields within and near the area of review are discussed in more detail in the following sections.

2. Elk Hills Field

The Tulare Formation in the Elk Hillsfield was referred to and treated as an exempt aquifer by the EPA when it authorized Class I [12] non-hazardous injection in two Tulare disposal wells for Elk Hills Power, LLC, under UIC Permit #CA200002 (Exhibit 14). In addressing public comments received during the review process (Exhibit 14-3), the EPA wrote that it "… had made the determination that the Tulare Formation within the Area of Review is an exempt aquifer." The area of review for the Elk Hills Power UIC permit was in section 18G, which has Tulare groundwater that is comparable in its poor quality to other areas of the Elk Hills field. The original UIC permit, dated February 21, 2001, was modified on June 3, 2004, to authorize two additional Tulare injection wells (Exhibit 14). As of June 2014, nearly 35 million bbls of Class I nonhazardous industrial fluids produced during the operation of the Elk Hills Power Plant were injected into the Tulare Formation in the 18G area of the Elk Hills field.

The Tulare Formation within the Elk Hills field has been described by the DOGGR as an exempt aquifer (Exhibit 14-9). The DOGGR also has treated the Tulare as an exempt aquifer by permitting Class II UIC injection projects, project expansions, and wells. The DOGGR's letters of approval for the two Elk Hills Tulare Class II injection projects and several project expansions are provided in Exhibit 14. A list of active, idle, and abandoned Tulare wastewater disposal wells in the Elk Hills field also is included in Exhibit 14. Individual scanned records for the Elk Hills Tulare disposal wells can be accessed online using the following link:

http://opi.consrv.ca.gov/opi/opi.dll/WellList?UsrP_ID=100222100&FormStack=Main%2CField%2CWellList&SortFields=PWT__WellTypeCode&NewSortFields=PWT__WellTypeCode&GotoPage=121&PriorState=Fld__Code%3D228%2CEncoded%3DTrue

The Tulare Formation has been used since July 1981 for injection of produced water. Although this was after the DOGGR's submittal of its April 1981 Primacy Application, it was 14 months before the EPA granted the DOGGR primacy on September 29, 1982. In this 14-month interim, the Tulare Formation in the Elk Hills field still was not included as

[12] Class I wells inject hazardous and nonhazardous industrial and municipal wastes below the lowermost underground source of drinking water (USDW). Injection occurs into deep, isolated rock formations that are separated from the lowermost USDW by layers of impermeable clay and rock.

an exempt aquifer in the Primacy Application. As a result, it was omitted as an exempt aquifer based on being a non-hydrocarbon producing zone being used for wastewater disposal.

The Tulare Formation in the Elk Hills field has produced oil since 1975. It was not shown as a producing zone in the 1973 version of *California Oil and Gas Fields* but was documented as a March 1975 discovery in in the DOGGR's 1998 version of *California Oil and Gas Fields* (Exhibit 6). Although the March 1975 discovery pre-dates the DOGGR's April 1981 Primacy Application, the Tulare Formation in the Elk Hills field was not included as an exempt aquifer based on hydrocarbon production. Both the pre- and post-Primacy versions of Elk Hills geologic information in *California Oil and Gas Fields* are included in Exhibit 6. The Elk Hills field has existing aquifer exemptions based on commercial oil production only for the following zones:

- Mya gas and Scalez zones in the San Joaquin Formation
- Mulinia, Bittium, Wilhelm, Gusher, and Calitroleum zones in the Etchegoin Formation
- Olig, Stevens and Northwest Stevens zones in the Monterey Formation
- Carneros and Agua zones in the Temblor Formation

3. Asphalto Oil Field

The Asphalto field lies directly to the southwest of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 7). The Tulare Formation in the Asphalto field was not exempted when the 1982 DOGGR-EPA MOA was approved but was exempted by the EPA on July 31, 2009, when a separate application requesting this exemption was approved. The interval that was exempted includes the entire section of the Tulare zone below the confining alluvial clay within the administrative limits of the Asphalto field. The Tulare Formation was granted an aquifer exemption for the following reasons:

1. It did not serve as an underground source of drinking water (USDW);
2. It had TDS concentrations greater than 3,000 mg/l: and
3. It was not reasonably expected by the WKWD to supply a public water system because of its poor groundwater quality.
4. It was so contaminated that it would have been economically or technologically impractical to render that water fit for human consumption.

It was demonstrated in the Asphalto Tulare aquifer exemption application that, because of high concentrations of TDS, chloride, sulfate, boron, Tulare groundwater could not be economically treated for use as drinking water. It will be demonstrated in this document that Tulare groundwater in the Elk Hills field is at least as poor in quality as Asphalto groundwater and therefore economically infeasible to treat for use as drinking water.

The following zones in the Asphalto field have aquifer exemptions based on commercial petroleum production:

- Etchegoin
- Olig, Stevens, and Antelope Shale in the Monterey Formation
- Carneros in the Temblor Formation

The Tulare Formation is the Asphalto field currently is being used for Class II injection.

4. Buena Vista Field

The northern boundary of the Buena Vista field adjoins the southern part of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 8). The Tulare Formation in the Buena Vista field was exempted under the 198 2 DOGGR-EPA MOA as a non - hydrocarbon producing zone being used for wastewater disposal and ha s an aquifer exemption within the entire administrative limits of the field. The other exempt aquifers were based on commercial petroleum production and include the following zones:

- Above Scalez, Sub Scalez One, and Sub Scalez Two zones in the San Joaquin Formation in the Buena Vista Front area
- Mulinia zone in the Etchegoin Formation in the Buena Vista Front area
- Mya (gas) zone in the San Joaquin Formation in the Buena Vista Hills Area
- Top Oil (Sub Scalez) zone in the San Joaquin Formation in the Buena Vista Front area
- Sub Mulinia, Wilhelm, Gusher, Calitroleum, 99 -90, and 27 -B (E sands) zones in the Etchegoin Formation in the Buena Vista Hills area
- Calidon (gas) zone in the Etchegoin and Monterey formations in the Buena Vista Hills area
- Antelope shale and 555 Stevens zones in the Monterey Formation in the Buena Vista Hills area

The Tulare Formation in the Buena Vista field currently is used for Class II was tewater disposal by Valley Water Management Company in section 19B.

5. Railroad Gap Oil Field

The Railroad Gap field is adjacent to the northeastern portion of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 9). The Amnicola zone is exempt only within the productive area of the Railroad Gap field, but this area is not shown on Exhibit 9. The following zones have aquifer exemptions based on commercial petroleum production.

- Amnicola zone in the Tulare Formation (lower Tulare)

- 2nd Mya (gas) zone in the San Joaquin Formation
- Olig zone , Antelope shale, and Valv (Foraminite) zones in the Monterey Formation
- Carneros, upper Santos, and Phacoides (Wygal) zones in the Temblor Formation

The upper part of the Tulare Formation in the Railroad Gap field is not an exempt aquifer. The Amnicola zone in the lower Tulare is exempted and was used in the past for steamflood and cyclic steam operations, but all wells have since been abandoned.

6. Midway-Sunset Oil Field

The northern part of the Midway -Sunset field is adjacent to the Elk Hills Tulare aquifer exemption area along its southwestern side (Exhibit 2; Exhibit 5; Exhibit 10). The following zones in the northern area of the field , which are shown as the shaded areas on some of the maps and cross -sections in Exhibit 10, have aquifer exemptions based on commercial petroleum production:

- Tulare Formation
- Mya Tar and Top Oil zones in the San Joaquin Formation
- Kinsey, Wilhelm, Gusher, and Calitroleum zones in the Etchegoin Formation
- Lakeview, Sub-Lakeview, Potter zones , Marvic, Antelope shale, Monarch, Webster, Moco, Obispo, Pacific, Metson, Leutholtz,, and Republic, in the Monterey Formation

Exempt Tulare aquifers currently serve or have served as Class II disp osal zones in the northern part of the Midway-Sunset field. The largest of these is operated by ValleyWater Management Company, which disposes into the Tulare Formation in sections 13 G, 19G, and 21G. The Tulare zone also is or has been steamflooded, water flooded, and cyclically-steamed in this field.

7. McKittrick Oil Field

The McKittrick field lies to the west of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 11). The following zones in the Main and/or Northeast areas of the McKittrick field all have aquifer exemptions based on commercial petroleum production (Exhibit 11)[13]:

- Tulare in the Main and Northeast areas
- Olig zone in the Monterey Formation in the Main and Northeast areas
- Basal Reef Ridge in the Monterey Formation in the Main area
- Stevens in the Monterey Formation in the Main area
- Antelope shale in the Monterey Formation in the Northeast area

[13] The exempt area of the Tulare Formation is only shown on one of the crosssections.

- Carneros and Phacoides zones in the Temblor Formation in the Northeast area
- Oceanic zone in the Tumey Formation in the Northeast area
- Point of Rocks zone in the Kreyenhagen Formation in the Northeast area

The Tulare zone in the McKittrick field is used for Class II wastewater disposal, steamflooding and cyclic steaming.

8. North Coles Levee Field

The western side of the North Coles Levee field lies along the northeastern area of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 12). In documentation from the EPA, the Tulare Formation in the North Coles Levee field was shown to have a TDS concentration of 12,900 mg/l prior to any injection (Exhibit 4-5) and therefore did not meet the definition of a protected USDW within the entire administrative limits of the North Coles Levee field.

The Tulare Formation in the North Coles Levee field was used for Class II wastewater disposal, but the well has not injected since January 1977 and has been abandoned.

9. South Coles Levee Field

The northwestern area of the South Coles Levee field adjoins the southeastern side of the Elk Hills Tulare aquifer exemption area (Exhibit 2; Exhibit 5; Exhibit 13). EPA documentation shows that the Tulare Formation in this field had TDS concentrations between 12,000 to 13,300 mg/l (Exhibit 4-5). Because TDS concentrations exceed the 10,000 mg/l threshold for being a protected USDW, the Tulare Formation within the entire administrative limits of the South Coles Levee field is not an USDW.

There is one active Class II wastewater disposal well in the Tulare-San Joaquin in the South Coles Levee field. Four other disposal wells in this zone have since been abandoned.

F. AQUIFER CHARACTERIZATION

1. Description of Aquifer

Topography shows that the Elk Hills field is deeply cut by canyons that trend either north or south from the crest of the hills (Exhibit 2). The crest of Elk Hills lies about 1,000 feet above the valley floor, and canyons commonly are 75 to 200 feet deep. All areas of topographic relief in the field have the Tulare Formation in outcrop (Exhibit 15).

The Tulare groundwater in the area of review lies within the Kern County Subbasin of the San Joaquin Valley Groundwater Basin (Exhibit 16; California Department of Water

Resources, 2006). The Kern County Subbasin has interior drainage and no appreciable surface or subsurface outflow, except during extremely wet years (Kern County Water Agency, 2008). The Elk Hills field lies within Detailed Analysis Unit (DAU) Nos. 259 and 260 of the Kern County Subbasin (Exhibit 17; California Regional Water Quality Control Board, 2004). The designated beneficial uses for DAU No. 259 are MUN, AGR, and IND. The designated beneficial uses for DAU No. 260 consist only of MUN and IND.

The structure and stratigraphy of the Tulare Formation within the area of review is shown in the type logs (Exhibit 18), the structure contour map of the base of the Tulare Formation (Exhibit 19), the isochore map of the gross thickness of the Tulare Formation (Exhibit 20), and structural cross-sections (Exhibit 21).

The Tulare Formation is the primary groundwater-bearing zone in the Elk Hills field. It consists of fluviatile and lacustrine deposits of gravel, sand, silt, clay, and limestone. The Tulare Formation at Elk Hills contains three informal members: the upper and lower Tulare and, separating the two, the Amnicola claystone. The Tulare contains nonmarine sediments deposited in floodplain, fluvial channel, and lake environments. Fluvial channels are coarse- to very coarse-grained and fine upward to medium- and coarse-grained sand. Porosity and permeability are very good. Sand intervals are generally loose and unconsolidated. Floodplain sediments consist of clay and sandy siltstone. The Amnicola claystone consists of silty claystone and probably was deposited in a lacustrine setting. Floodplain deposits are more common in the lower Tulare, whereas fluvial channels comprise most of the upper Tulare.

Two prominent lacustrine clay or claystone units occur within the Tulare Formation and can act as effective confining zones. The Amnicola claystone, which separates the upper and lower Tulare, consists of a dark brown-gray, lacustrine claystone with thin, rare siltstones. The Tulare clay occurs within the upper part of the formation and is a thick unit of clay and interbedded clay-gravel. The portion of the Tulare Formation above the Amnicola claystone has the best porosity and permeability and is the most suitable zone in the Elk Hills field for produced water injection.

In the aquifer exemption area, the Tulare Formation conformably overlies the shallow marine deposits of the San Joaquin Formation (Exhibit 18 through Exhibit 21). The San Joaquin Formation lying immediately beneath the Tulare is composed of shale and silt and contains characteristic marine fossils and shells. It produces natural gas and formation water with high TDS concentrations.

Across most of the Elk Hills field, the Tulare Formation crops out at the surface. Holocene age alluvium is present only at the most down-dip flanks of the field to the north, south, and east. The contact between the top of the Tulare, where present, and the base of the alluvium was originally established by geologic mapping (Woodring et al., 1932) and later refined using aerial photographs.

The base of Tulare Formation was based on the definition used by the U. S. Geological Survey (USGS) in Maher et al. (1975). It was placed at the transition between the marine tidal marsh and channel deposits of the San Joaquin Formation and the fluvial and lacustrine sands of the Tulare. Correlations of the first Tulare sand are relatively consistent across Elk Hills. A higher well density based on recent well data allowed a more accurate view of correlations, and USGS tops were modified locally as improved correlations were identified.

The base of the Tulare Formation in the subsurface ranges from elevations of +500 feet in the axial crest of the anticline to -2,500 feet in the Buena Vista Valley area (Exhibit 19). Although only a single major anticline is present in the surface outcrops of Elk Hills, two culminations are apparent at the base of the Tulare Formation: the western 29R Anticline in sections 28R and 29R and the eastern 31S Anticline in sections 25R, 36R, 30S, and 31S. At the south edge of the map, the Buena Vista Syncline can be recognized in section 14G, and, further to the south, the edge of the Buena Vista Anticline is apparent.

The gross thickness of the Tulare Formation ranges from about 1,100 feet along the axial crest of Elk Hills to more than 2,500 feet on the north flank and 3,000 feet in the Buena Vista Valley (Exhibit 20). Flank thickness may include alluvium because it is difficult to differentiate it from the Tulare in these areas.

Five significant normal faults break only the base of the Tulare Formation in eastern Elk Hills area. These are extensions of deeper faults that reach reservoirs in the San Joaquin and Etchegoin Formations. Faults have up to 300 feet of offset. The downthrown blocks are to the northwest.

From a hydrogeologic standpoint, the Tulare Formation can be divided into two zones: 1) the shallow unsaturated Tulare zone and 2) the deeper, saturated Tulare zone. The Tulare aquifer exemption interval includes all of the saturated upper Tulare zone and both the unsaturated and saturated lower Tulare below the Amnicola claystone confining zone.

a. Unsaturated Tulare Zone

The upper intervals of the Tulare Formation consist of sand, conglomerates, and finer-grained sediments that are completely dry or at irreducible water saturation and are referred to in this document as the unsaturated Tulare zone. The extent of the unsaturated Tulare zone, which occurs in the area of the axial crest of Elk Hills, is shown as the yellow highlighted area in Exhibit 20. The unsaturated Tulare zone below the Amnicola claystone confining zone is part of the aquifer exemption interval.

The structure map of the base of the unsaturated Tulare zone was made by finding the lowest occurrence of the density-neutron crossover in the Tulare in each well (Exhibit

22). In some instances and mostly in outlying areas, resistivity was used when the density and neutron curves were absent. In these cases, the base of the unsaturated Tulare zone was picked where resistivity drops from consistently higher values (>10 ohm-m) to lower values (<5 ohm-m) in clean sands.

The base of the unsaturated Tulare zone is not necessarily the same as the top of the saturated Tulare zone. Actual air-water contacts are rare in the data set because individual Tulare sand beds generally are too thin to recognize these contacts. The base of the unsaturated interval is more consistent in the upper Tulare because it is a more sand-rich section. Where the unsaturated base occurs in the lower Tulare, the horizon is more variable because of the low net sand that is characteristic of the interval.

Along the crest of Elk Hills, the base of the unsaturated zone is coincident with or close to the base of the Tulare Formation. In these areas, the unsaturated Tulare zone reflects the structure formed by the Elk Hills anticline. On the flanks of the Elk Hills anticline, the base of the unsaturated Tulare is relatively horizontal and can cross the dipping strata of the Tulare. Where the Tulare has a low net sand content, typically in the lower Tulare, the base of unsaturated interval is more variable. Although the Amnicola claystone is a well-documented confining zone in the Elk Hills area, the base of the unsaturated zone can be at a relatively similar level in the upper and lower Tulare. This may be because: 1) groundwater levels may be slightly different but masked by the variability of the mapping methods or the age of the well logs, and 2) the base of the unsaturated Tulare zone may be influenced more by the structural growth of the Elk Hills anticline and a weak groundwater system that has no appreciable recharge and low pressures, resulting in groundwater levels in both Tulare members reaching similar levels. Other cross-sections also show slightly different groundwater levels between the lower and upper Tulare, particularly in the south flank area (Exhibit 21-1; Exhibit 21-2), in the eastern and western Elk Hills area (Exhibit 21-3) and to a lesser extent on the north flank (Exhibit 21-2). The elevation of the base of the unsaturated Tulare zone ranges from about +80 feet in the northwestern area to +520 feet in the area of sections 28R and 29R (Exhibit 22).

The isochore map of the gross thickness of the unsaturated Tulare zone represents the difference between the ground surface elevation on the topographic map and the elevation of the base of the unsaturated Tulare zone grid (Exhibit 23). Contours are very crenulated because of the deep erosion of the ground surface. The yellow area shows that 100% of this interval is unsaturated, as indicated by the density-neutron crossover. At the crest of Elk Hills, there are up to 1,100 feet of unsaturated Tulare zone. The unsaturated interval thins to less than 100 feet off the northeastern and southeastern flanks of Elk Hills. Where present, some of this outlying interval may include alluvium because it is difficult to differentiate it from the uppermost Tulare Formation.

It is important to note that the isochore map of the gross thickness of the unsaturated Tulare zone is based on density-neutron log coverage. The surface to the top of the logged interval, typically 50 to 300 feet thick, is included in this map. Shallow boreholes drilled across several sections in Elk Hills confirm that the uppermost interval of the Tulare also is unsaturated. An example of some of the data used to determine if shallow perched groundwater is present in the Tulare zone is included for the Stantec 43-36R in Exhibit 24[14]. Based on these boreholes, the deeply eroded Tulare surface, and the dip of the anticlinal limbs of the Elk Hills structure, it is unlikely that there would be any naturally-occurring, saturated sands in the shallowest Tulare Formation in Elk Hills.

b. Saturated Tulare Zone

The saturated Tulare zone can occur either above or below the Amnicola clay stone in the Tulare Formation, both of which are part of the Tulare aquifer exemption interval (Exhibit 21). The isochore of the gross thickness of the saturated Tulare represents the unedited difference between the base of the unsaturated Tulare zone and base of the Tulare grids (Exhibit 25). The yellow area on the isochore map shows where the entire interval of the Tulare is unsaturated. In this area, there may be as much as 40 feet of interval below the base of the unsaturated Tulare zone which is included in the unsaturated zone. This is because the base of the Tulare can contain no clean sand that would trigger the density-neutron crossover effect.

The gross thickness of the saturated Tulare zone ranges from 0 feet along the axial crest of Elk Hills to greater than 2,500 feet in the north flank area and 2,800 feet in the Buena Vista Valley on the south flank. In sections 25R and 26R, there is a small lens of saturated zone in the lower Tulare within the yellow-colored, unsaturated interval. This area is coincident with the saddle between the 31S and 29R Anticlines and may contain groundwater in sands at the base of the Tulare, with a maximum gross thickness of 200 feet.

Groundwater in the saturated Tulare zone can occur under unconfined or semi-confined conditions where confining strata are absent or below the Amnicola claystone in the axial crest area (Exhibit 21). Saturated Tulare sands also can occur under confined conditions, especially below the Amnicola claystone along the flanks of Elk Hills (Exhibit 21).

[14] Additional data from the Stantec 43-36R borehole as well as other boreholes in the Elk Hills field are not included in this document but are available upon request.

2. Depth of Aquifer

   The saturated Tulare zone is not present over the axial crest area of the Elk Hills field. Where present, the depth to the base of the unsaturated Tulare zone ranges from about 380 feet in the 18G area to 1,050 feet in the 30R (Exhibit 22). As discussed in Section F.1.a, the base of the unsaturated Tulare zone is not necessarily the same as the top of the saturated Tulare zone because individual Tulare sand beds generally are too thin to recognize air-water contacts.

3. Lateral Extent of Aquifer

   The Tulare aquifer is laterally continuous throughout the area of review, except on the crest of Elk Hills where there is no saturated zone (Exhibit 19; Exhibit 20; Exhibit 21). The Tulare Formation is stratigraphically continuous between the area of review and the surrounding fields in which it already is an exempt aquifer.

4. Drinking Water Wells within the Area of Review

   All water well drillers in California are required to submit Well Completion Reports to the DWR, which shares these data with the KCWA. Water well records within the area of review were searched using data from the KCWA, the Department of Water Resources (DWR) Water Data Library, the DWR California Statewide Groundwater Elevation Monitoring Program, the Kern County Environmental Health Services Department (KCEHSD), the USGS National Water Information System, and USGS Professional Paper 912. The summary of results from the water well survey is provided in Exhibit 26. There were no water wells records within the area of review in the KCEHSD database. However, KCEHSD only keeps records of well destructions for about five years before they are discarded. Also, the agency did not begin keeping records of water wells until the mid-1980s.

   The current status[15] of the water wells in all agency databases was verified by site reconnaissance by Quad-Knopf (Exhibit 26). Based on searches of water well databases, well records review, and site reconnaissance, there are no known drinking water wells located within the area of review. The WKWD is the primary supplier of municipal and industrial water in this area. The WKWD has no water wells within the area of review and has no rights to drill any water wells within Elk Hills Tulare aquifer exemption area.

[15] Active, idle, or destroyed.

G. TYPES OF CONSTITUENTS AND TDS IN FORMATION WATER

Tulare groundwater was characterized based on a review of laboratory analyses and reports provided by OEHI, DOGGR Class II UIC project information, DOGGR formation water analyses for fields in and near the Elk Hills area, and literature on groundwater in the area of review.

Groundwater samples from the Tulare Formation in the Elk Hills field were grouped into two main areas based on data from the following wells:

- **South Flank Area**

  43WS-13B, 84WS-13B, and 284WS-13B

  82-14B and 282WS-14B

  Test wells 48-9G and the 57WS-9G

  45WS-18G and 86WS-18G

  82-2B

- **North Flank Area**

  61WS-8R

Nearly all of the Tulare groundwater analyses were collected from Tulare water source wells on the south flank of the Elk Hills field. All Tulare water source wells either have been abandoned or are idle. Tables summarizing the average concentrations of Tulare groundwater constituents and laboratory analyses from individual wells are included in Exhibit 27.

1. South Flank Tulare Groundwater

The initial TDS concentrations for Tulare water source wells completed above the Amnicola claystone ranged from 4,150 to 8,720 mg/l (Exhibit 27). Below the Amnicola claystone, the initial TDS concentrations range from 7,168 to 20,000 mg/l (Exhibit 27). In the lower Tulare, where TDS concentrations exceed 10,000 mg/l, groundwater in that interval is not a protected USDW by definition. TDS concentrations in Tulare groundwater generally show a trend of increasing with depth. It is likely that this results from proximity to the underlying marine San Joaquin Formation as well as other deeper, marine rocks that contain naturally saline, connate groundwater.

A summary of these constituents and their regulatory thresholds is provided in Table 1.

Table 1

Constituents in Tulare Formation Water, South Flank Wells

Constituent	Mean Concentration or Range	MCLs and Regulatory Thresholds	Threshold Exceeded?	% of Threshold
Lead[1]	0.0208	0.015	Yes	139%
Selenium[2] (below Amnicola)	0.720	0.05	Yes	1440%
Iron	<0.1 to 37	0.3	In some analyses	Up to 12,333%
TDS[3] (above Amnicola)	4,150 to 8,720	500	Yes	830% to 1,744%
TDS[3] (below Amnicola)	7,168 to 20,000	500	Yes	1434% to 4,000%
Chloride[4]	1,625	250 (recommended)	Yes	650%
Sulfate[5]	1,435	250 (recommended)	Yes	574%
Boron[6]	6.16	<0.5 - >3.0	Yes	205% to 1,232%
Strontium[7]	5.0 to 6.8	4	Yes	125% to 170%
Sodium[8]	1,217	<3 to <69	Yes	1,764% to 40,567%
Arsenic	0.0047	0.010	No	--
Copper	<0.04+	1.0	No	--
Molybdenum	0.103	None	--	--
Nickel	0.0559	0.1	No	
Zinc	0.049 to 0.0589	5.0	No	--

NOTES:

All concentrations and regulatory limits are in mg/l.

Primary MCLs are shown in red.

Secondary MCLs are shown in orange.

Other regulatory thresholds are shown in yellow.

[1]The MCL for lead is 0.015 mg/l, and its maximum contaminant level goal (MCLG) is 0 mg/l. The environment screening level (ESL) for lead in groundwater is 0.0002 mg/l.

[2]Primary MCL for selenium: 0.050 mg/l

[3]Secondary MCLs for TDS: recommended = 500 mg/l; upper = 1,000 mg/l; short term = 1,500 mg/l

[4]Secondary MCLs for chloride: recommended = 250 mg/l; upper = 500 mg/l; short term = 600 mg/l. The chloride water quality guideline for sprinkler irrigation is <106 mg/l. Irrigation water for sensitive crops is recommended to be <142 mg/l.

[5]Secondary MCLs for sulfate: recommended = 250 mg/l; upper = 500 mg/l; short term = 600 mg/l.

[6]The EPA's lifetime health advisory (LHA) for boron is 6 mg/l, and its drinking water equivalent level (DWEL) for boron is 7 mg/l. Boron concentrations as low as 0.5 mg/l may be toxic to certain sensitive plants; severe usage restrictions are recommended for concentrations greater than 3.0 mg/l. The upper limit for livestock drinking water is 5.0 mg/l.

[7]The EPA's LHA level for strontium is 4 mg/l for a 70-kg adult consuming 2 liters water/day.

[8]Recommended sodium levels for surface irrigation, which are based on toxicity from root absorption, are <3 mg/l) and for sprinkler irrigation are <69 mg/l. f

(Source: NPR-1 Ground Water Monitoring Plan, 1995 and groundwater analyses in Exhibit 27)

Tulare groundwater in the Elk Hills south flank area has: 1) a concentration of lead that exceeds the primary MCL for drinking water; 2) TDS, chloride, and sulfate concentrations in excess of secondary drinking water MCLs in every groundwater analysis ; 3) b oron, strontium, and sodium concentrations in excess of regulatory thresholds for human health, agricultural uses, and/or livestock watering; and 4) iron concentrations that are variable but exceed the secondary drinking water MCL in some analyses.

Some areas of the south flank have TDS concentrations in Tulare groundwater in excess of 10,000 mg/l, shown in green in the cross -sections in Exhibit 21. Tulare groundwater in these areas, typically near its base, does not meet the definition of a protected USDW and automatically qualify those zones as exempt aquifers. An example of groundwater quality in a non-protected USDW is included in Exhibit 27 for the 82-2B well. This south flank well is completed only in the lower Tulare interval. Groundwater analyses from the 82-2B well had a TDS concentration of 20,000 mg/l . It also has : a concentration of selenium which exceeds the primary MCL; chloride and sulfate concentrations in excess of recommended secondary MCLs: and concentrations of boron , strontium, and sodium greater than regulatory thresholds for protection of human health , agriculture, and /or livestock.

2. North Flank Tulare Groundwater

The 61WS-8R well, located in the northwestern part of the field, averaged 7,009 mg/l TDS in 1979 (Exhibit 27-1); Bechtel Petroleum Operations, Inc., 1994) . When groundwater from this well was analyzed on May 17, 1988, TDS had increased to 8,720 mg/l . TDS concentrations in the 61WS-8R well exceed secondary MCLs for drinking water by 1,744%. Other analyses from 61WS-8R were: chloride 2,262 mg/l; sulfate 1,295; and boron 10 mg/l, all of which were significantly in excess of secondary MCLs and regulatory thresholds for human health, agricultural use, and livestock watering.

3. Characterization Summary for Tulare Groundwater in the Elk Hills Field

Tulare groundwater constituents from two areas of the Elk Hills field are summarized below (Table 1; Table 2; Exhibit 27).

- One Tulare groundwater sample in the south flank of the Elk Hills field contained a concentration of lead that exceeds the primary MCL for drinking water.
- Every Elk Hills Tulare groundwater analyses in Exhibit 27 had TDS, chloride, and sulfate concentrations that significantly exceed secondary MCLs for drinking water.
- Iron concentrations in Tulare groundwater are variable, ranging from undetectable to significantly higher than secondary MCLs (Exhibit 27).
- All Tulare groundwater analyses of boron and sodium in Exhibit 27 exceed regulatory thresholds for human health, agricultural uses, and/or livestock watering.
- Although strontium was analyzed in only four Tulare groundwater samples, it exceeds the regulatory threshold for human health in all four analyses.

Where TDS concentrations are less 10,000 mg/l TDS , Tulare groundwater generally is of extremely poor quality and unfit for MUN (Table 1 through Table 2) and AGR purposes

(Table 3). Areas of the Elk Hills field have Tulare groundwater with TDS concentrations in excess of 10,000 mg/l. These areas, which typically occur near the base of the Tulare, are shown in green shading on the cross-sections in Exhibit 21. These high TDS zones in the lower Tulare do not meet the definition of a protected USDW and therefore would be exempt aquifers. The Tulare Formation in the Elk Hills fieldalso has producible quantities of hydrocarbons and/or oil and gas shows, particularly in the areas of sections 19R, 28R, 29R, 30R, 33R, 31S, 13Z, 14Z, and 25Z, as discussed in Section I of this document. Hydrocarbons, even if not commercial, represent an additional contaminant to be removed if Elk Hills Tulare groundwater were to be treated for use as drinking water.

Table 2: Summary of Tulare Groundwater Constituents

Constituent	Range (mg/l)	Primary or Secondary MCL (mg/l)	Regulatory Threshold (mg/l)*
Lead	0.0208	0.015	0 to 0.0025
Selenium	Below Amnicola: 0.720	0.050	
Iron	<0.1 to 37	0.3	
TDS	4,150 to 8,720 Below Amnicola: 7,168 to 20,000	500 (recommended)	>2,000
Chloride	1,000 to 6,049.5	250 (recommended)	>3 to >10
Sulfate	340 to 1,800	250 (recommended)	
Boron	3.7 to 10.0	--	0.0016 to 7
Sodium	856 to 1,800	--	<3 to <69
Strontium	5.0 to 6.8		4.0
Hydrocarbons	Variable	--	--

*See regulatory thresholds in Table 1 through Table 3.

Table 3: Guidelines for Interpretations of Water Quality for Irrigation

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity *(affects crop water availability)*[2]				
EC_w	dS/m	< 0.7	0.7 – 3.0	> 3.0
TDS	**mg/l**	**< 450**	**450 – 2000**	**> 2000**
Specific Ion Toxicity *(affects sensitive crops)*				
Sodium (Na)[4]				
sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl)[3]				
surface irrigation	me/l	< 4	4 – 10	> 10
sprinkler irrigation	me/l	< 3	> 3	
Boron (B)[4]	**mg/l**	**< 0.7**	**0.7 – 3.0**	**> 3.0**
Trace Elements (see Table 21)				
Miscellaneous Effects *(affects susceptible crops)*				
Nitrogen ($NO_3 - N$)[5]	mg/l	< 5	5 – 30	> 30
Bicarbonate (HCO_3)				
(overhead sprinkling only)	me/l	< 1.5	1.5 – 8.5	> 8.5
pH		Normal Range 6.5 – 8.4		

[1] Adapted from University of California Committee of Consultants , 1974 (See Ayers & Westcot, 1994).

[2] Ecw means electrical conductivity, a measure of the water salinity, reported in deciSiemens per mete r at 25°C (dS/m) or in units millimhos per centimeter (mmho/cm). Both are equivalent. TDS is reported in mg/l.

[3] For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most an nual crops are no t sensitive; use the salinity tolerance tables (Ayers & Westcot Tables 4 and 5). For chloride tolerance of selected fruit crops, see Ayers & Westcot, 1994, Ayers & Westcot Table 14. With overhead sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops. For crop sensitivity to absorption, see Ayers & Westcot, 1994, Ayers & Westcot Tables 18, 19 and 20.

[4] For boron tolerances, see Ayers & Westcot, 1994, Ayers & Westcot Tables 16 and 17.

[5] NO_3 –N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4 –N and Organic-N should be included when wastewater is being tested).

In the area surrounding the Elk Hills field, TDS concentrations in Tulare groundwater also are naturally high (Exhibit 29). Regional studies of groundwater in the western San Joaquin Valley confirm that high concentrations of salts in Tulare groundwater are the result of: 1) naturally saline, connate waters; 2) migration of brines from deeper zones by the same processes that caused local petroleum occurrences; 3) agency-permitted surface and subsurface disposal of briny produced water; and 4) enclosed groundwater basin geometry (Western Oil and Gas Association, 1983; Bean & Logan, 1983; Weddle, 1968).

4. Salinity Calculations[16]

Calculations of salinity in the Elk Hills field follow guidelines published by the EPA (Davis, 1988). The Humble equation was selected because its critical parameters, including deep resistivity and density porosity, are available for the calculations. Also known as the RP Method, the Humble equation is the most widely-used formula for unconsolidated sands (Davis, 1988) that are typical of the Tulare Formation. Discussion of the method used for salinity calculations is included in Exhibit 30.

Direct samples of water salinity are available only from a small group of wells at Elk Hills. In general, these wells are former Tulare water source wells. Water quality was sampled in order to analyze compatibility of Tulare groundwater with Miocene Stevens zone waterfloods. Most of these wells do not have full geophysical log suites. However, more recent nearby development wells or water disposal wells do have complete log suites. Therefore, it is possible to compare sampled water salinity to calculated salinity.

A limitation of this analysis is that the former Tulare water source wells were completed over a very long interval. As a result, multiple intervals of varying calculated salinities are present within the borehole and contribute to the groundwater sampled.

Well 48-9G has some of the best water salinity information at Elk Hills. Two intervals in the lower Tulare were tested: an upper interval from 595 to 935 feet, and a lower interval from 1,040 to 1,275 feet (Exhibit 30). Two water samples from the upper interval had salinities of 7,453 and 7,168 mg/l TDS. Three samples from the lower interval, taken over a week-long period, changed from 12,647 to 9,926 ppm TDS. The change in salinity may be caused by increased flow from more permeable sands having lower salinity. Three nearby wells, located within 600 feet of 48-9G, were selected for calculation of salinity. The three wells record a progressive increase in salinity, from shallow to deep, generally ranging from about 6,000 mg/l TDS at about a measured depth of 600 feet to greater than 13,000 mg/l TDS near the base of the Tulare For both the upper and lower tested intervals, all sampled formation water salinity measurements fell within the range of calculated salinity values in stratigraphically equivalent intervals, and the principle that salinity increases with depth in the Tulare Formation is well-established in this example.

[16] This discussion of salinity calculations and all of Exhibit 30 were prepared by Mr. Stephen A. Reid of OEHI, California-licensed Professional Geologist No. 3876.

Three Tulare water source wells have measurements of formation water salinity and also have nearby wells with modern geophysical suites that permit the calculation of salinity using the Humble equation. Wells 45WS-18G and 86W-18G were completed over an interval of more than 1,000 feet and have measured salinities of 4,700 to 5,800 mg/l TDS (Exhibit 30). Nearby wells, which are located within 1,700 feet, have calculated salinity values that bracket the measured values. Likewise, well 284WS-13B had an initial salinity test of 5,744 mg/l TDS initially but declined to 4,500 mg/l after a year (Exhibit 30). Calculated salinity in nearby well 54WD-13B, located 1,580 feet west, ranges from 4,000 mg/l TDS in the shallow interval to 5,000 mg/l in the deep. The occurrence of initially higher salinity in tests is attributed to contributions of formation water from below the calculated zones in the nearby well. Over time, shallower and more permeable zones began to dominate production in the water source well. Just as in the structurally higher parts of Elk Hills, salinity increases with depth in the flank areas as well.

Elk Hills calculated salinity data compare closely to actual measured groundwater samples, or, more frequently, calculated values are less than actual groundwater sample values, with the error amount up to 30%. In no case do calculated values exceed actual groundwater samples values by more than 1%. The error may be caused by the large amount of open interval and that deeper, higher salinity formation water makes up a significant portion of the sample. In wells with more restricted sample intervals, such as 48-9G and 82-2B, errors ranged from 6 to 21%. This amount of error is consistent with that noted by Davis (1988). Based on this comparison, calculated salinity is equal to or less than values from actual tested groundwater samples.

Calculated salinity values of groundwater-bearing intervals of the Tulare Formation show a trend of increasing salinity with depth. Salinity in the upper Tulare on the flanks of Elk Hills has values between 3,500 and 6,000 mg/l TDS. Calculated salinities in sand intervals below the Amnicola claystone range from 6,000 to 24,000 mg/l TDS. Salinity in at least the lowermost 240 feet of the basal Tulare is greater than 10,000 mg/l TDS. This calculation of high salinity is confirmed by formation water tests in well 48-9G. Comparison of calculations using the RP method, or Humble equation, and formation water tests shows that calculated salinity is equal to or less than the actual groundwater analyses, but the underestimation error is no more than 21%.

H. YIELD OF GROUNDWATER

1. Permeability

Conventional core analyses from wells in the Elk Hills field were used to determine permeability in the Tulare Formation. Based on Tulare sand and sandstone units in the Bechtel UONPR #1 CH-27R and the Williams Brothers 36-30R, the average vertical and horizontal permeabilities are 1,314 millidarcies (md) and 2,723 md, respectively (Exhibit 31-1). The range of permeability is quite large because of the poor sorting of the nonmarine Tulare sediments. The permeability of these units is believed to be representative of Tulare injection zones.

In the clay, silt, and siltstone units of the Tulare Formation, the vertical permeabilities range from <0.1 to 1.0 md and averages 0.7 md (Exhibit 31-2). The low vertical permeabilities of the fine-grained Tulare units demonstrate that these zones would act as effective barriers to upward migration of fluids.

Permeabilities in the area of section 30R, where the Tulare produced oil, were analyzed by Bergeson (1988). The whole curve average of 159 conventional core and sidewall samples was 434 md (Exhibit 31-3). In a 15-foot interval of "good" Tulare oil sand, the average permeability was 374 md.

2. Porosity

The porosity of the Tulare Formation was based on analyses of conventional core analyses from two wells in the Elk Hills field. The average porosity of the Tulare sand and sandstone units, which is considered to be representative of Tulare injection zones, is 35.8% and ranges from 12.3% to 44.2% (Exhibit 31-1). The clay, silt, and siltstone units of the Tulare Formation have an average porosity of 30.7% and ranges from 24.9% to 38.6% (Exhibit 31-2).

Porosity also was analyzed in the area of section 30R, where the Tulare produced oil (Bergeson, 1988). Based on 159 conventional core and sidewall samples, the whole curve average was 38.0% and 38.7% in a 15-foot interval of "good" Tulare oil sand (Exhibit 31-3).

3. Sand Identification

Sand can be readily identified on logs as those intervals having spontaneous potential deflections to the left and resistivity deflections to the right (Exhibit 18; Exhibit 21).

4. Fluid Levels

Initial static fluid levels from wells on the south flank of Elk Hills ranged from 247 feet to 323 feet (Table 4).

Table 4: Initial Static Fluid Levels in South Flank Area Wells

Well No.	Elevation (feet MSL)	Year
84WS-13B	252	1979
284WS-13B	255	1990
43WS-13B	284	1992
82WS-14B	323	1980
282WS-14B	289	1990
48-9G	273	1978
57WS-9G	305	1979
86WS-18G	247	1982
45WS-18G	250	1991

(Source: Phillips, 1992)

I. TULARE OIL AND GAS PRODUCTION

Oil and gas in the Tulare Formation occur in both commercial and, at the time, sub-commercial quantities in several areas of the Elk Hills field:

- Oil production: Abandoned wells in the 30R area near the western side of the field, shown within the green box in Exhibit 32-1.
- Active gas production: 461-31S area in the central area of the field (Exhibit 1). Production data for this well can be accessed using the following link:

  http://opi.consrv.ca.gov/opi/opi.dll/WellFrame?UsrP_ID=100237135&PWT__ID=100260528&PWT__WellTypeCode=OG&StartRow=4601&SortFields=WMtr_OperatorWellNumber&NewSortFields=WMtr_OperatorWellNumber&FormStack=Main%2CField%2CWellList&PriorState=Fld__Code%3D228&UsrP_RecentYearFirst=1

- Shut-in gas production: Well 456-28R in the west-central area of the field, shown in the red in Exhibit 32-1.

A summary of Tulare production data in the Elk Hills field is provided in Table 5. Cumulative production from the Tulare Formation in the Elk Hills field is 17,657 bbls oil and 282,094 Mcf gas. Hydraulic fracturing has not used in the past for Tulare oil and gas development and is not planned to be used in the future because it would have no benefit to petroleum production. Detailed maps of Tulare petroleum occurrences in Exhibit 32 were based on analyses and/or descriptions of conventional and/or sidewall cores and log data.

Table 5: Tulare Oil and Gas Production and Shows

Year	Comments
1960	5-6-15Z: Tested Tulare from 932' to 973' in the Railroad Gap field, located about 0.5 mile west of the Elk Hills field administrative boundary. Produced a peak gas of 642 Mcf gas/day. Shut-in in 1964; plugged 1967.
1975	1975 discovery of Tulare oil in the 46-30R well, as cited in the 1998 version of the DOGGR's *California Oil and Gas Fields* (Exhibit 6).
1978	48-9G: Tested Tulare (585'-1275') for potential water source well Had slight gas blow during swabbing; set unit and pump-tested for 2 months. Cumulative gas production: 13,878Mcf. Formation water rate too small for source well. Plugged well in 1999.
1984	Tulare steam cycle pilot, 30R area, 6 wells . Coring data showed oil saturation ; produced small oil rates during pilot. All wells plugged. 26NE-30R: 318 bbls oil, no gas; 26E-30R: 1780 bbls oil, no gas 27NE-30R: 654 bbls oil, no gas; 36-30R: 71 bbls oil, no gas 36E-30R: 6291 bbls oil, no gas; 36NE-30R: 3822 bbls oil, no gas 46-30R: 4721 bbls oil, no gas
2007	461-31S: Opened Tulare (692'-830'). Still producing commercial gas. Latest test: 0 bbls oil / 0 bbls water / 131 Mcf gas/d. Cumulative gas production: 282 MMcf.
2008	456-28R: Recompleted as gas producer in the Tulare (848'-981'). Currently idle.

The occurrence of producible hydrocarbons in local areas of the Elk Hills field would justify an aquifer exemption based on 40 CFR §146.4(a)(3) because it is hydrocarbon -producing or can be demonstrated by the permit applicant as part of a permit application for a Class II operation to contain minerals or hydrocarbons that, considering their quantity and location, are expected to be commercially producible. The Tulare Formation in the Elk Hills field has produced oil since 1975 and was documented as a March 1975 discovery in the DOGGR's 1998 version of *California Oil and Gas Fields* (Exhibit 6). Although the March 1975 discovery pre-dates the DOGGR's April 1981 Primacy Application, the Tulare Formation in the Elk Hills field was not included as an exempt aquifer based on hydrocarbon production.

It is important to note that the Tulare Formation historically has not been the main target of exploration and development in the Elk Hills field and therefore has relatively little data, such as geophysical logs, mud logs, or cores, to evaluate its commercial potential. Although its past production history and oil and gas shows are good indicators , the commercial oil and gas potential of the Tulare Formation will depend on evaluation of this zone during future drilling.

Commercial and sub -commercial quantities of hydrocarbons render the Tulare groundwater unfit for MUN, AGR, and IND uses and contribute to the economic infeasibility of treating it for use as drinking water , indicating that it should be classified as Class III groundwater, or groundwater that is not a source of drinking water, as discussed in Section L of this document.

J. DISPOSAL ACTIVITIES IN WITHIN THE AREA OF REVIEW

1. Class I Non-Hazardous Injection Operations

   The EPA has referred to and treated the Tulare Formation in the Elk Hills field as an exempt aquifer by when it authorized Class I non-hazardous injection in two Tulare disposal wells for Elk Hills Power, LLC, under UIC Permit #CA200002 (Exhibit 14-1, -2, -4, and -5). In addressing public comments received during the review process, the EPA wrote that it "… had made the determination that the Tulare Formation within the Area of Review is an exempt aquifer" (Exhibit 14-3). The area of review for the Elk Hills Power UIC permit was in section 18G, which has Tulare groundwater that is comparable in its poor quality to other areas of the Elk Hills field.

   The original UIC permit, dated February 21, 2001,was for Elk Hills Power wells 15-18G[17] and 35-18G. The permit was modified on June 3, 2004, to authorize two additional Class I non-hazardous injection wells, 25A-18G and 35A-18G (Exhibit 14). Nearly 35 million bbls of industrial, nonhazardous fluids produced during the operation of the electrical power plant were injected into the Tulare Formation in the 18G area.

2. Class II Injection Operations

   The Tulare Formation has been described as an exempt aquifer by the DOGGR (Exhibit 14-9) and used extensively for permitted injection operations in the Elk Hills field as well as in adjoining fields. In the Elk Hills field, the Tulare Formation has been used since July 1981 for injection of produced water. Two Class II UIC injection projects, #22800002 and #22800022, and several project expansions were permitted by the DOGGR for Tulare disposal operations in the Elk Hills field (Exhibit 14; Table 6). Injectate consists of produced water from the Shallow Oil Zone and the Stevens sand. Concentrations of TDS, chloride, and iron in the injectate significantly exceed the secondary MCLs for drinking water, and boron exceeds regulatory thresholds for human health, agricultural uses, and livestock watering, shown in red in Table 6. Since July 1981, more than 1,063,396,000 bbls of injectate have been disposed in the Tulare Formation through more than 130 wastewater disposal wells (Table 7; Exhibit 14).

[17] 15-18G in the UIC permit of 2/21/01 has the same location as the 2518G well in the modified UIC permit of 6/3/04.

Table 6

Class II UIC Injectate Data

Permit No.	Project Name, Zone, and Location	Injectate Source	TDS (mg/l)	Cl (mg/l)	Fe (mg/l)	B (mg/l)
22800002	**Tulare Water Disposal** Sec. 12B and 13B Sec. 24Z Sec. 7G, 8G, 10G, 17G, and 18G	Shallow Oil Zone; Stevens	**28,000**	**16,000**	**100**	**76**
22800022	**Lower Tulare Water Disposal** Sec. 20G, 21G, 22G, 27G, and 28G E	Stevens	**27,000**	**15,000**	**1.7**	**84**

NOTES:
Data obtained from the OEHI 2011 Annual Project Reviews.
Data shown in red exceed MCLs or regulatory thresholds for human health, agricultural use, or livestock watering.
Secondary MCLs: TDS = 500 mg/l (recommended); Cl = 250 (recommended); Fe = 0.3 mg/l.
Chloride >10 mg/l has severe restriction for surface irrigation use.
The ESL for boron in groundwater = 0.0016 mg/l.
Boron >3.0 mg/l has severe use restrictions for irrigation.

Table 7: Tulare Disposal Volumes

Year	Disposal Volume (bbls)
1980	0
1981	2,149,817
1982	10,975,563
1983	14,019,377
1984	14,056,873
1985	17,870,990
1986	17,259,402
1987	25,263,957
1988	28,367,531
1989	32,356,682
1990	32,249,891
1991	29,862,723
1992	27,936,213
1993	30,802,504
1994	31,266,415
1995	28,989,662
1996	26,053,964
1997	21,708,305

Year	Disposal Volume (bbls)
1998	20,316,512
1999	14,481,234
2000	18,544,647
2001	19,686,031
2002	26,958,706
2003	33,667,630
2004	23,257,711
2005	30,977,347
2006	41,605,661
2007	56,500,291
2008	59,315,147
2009	52,931,620
2010	53,974,091
2011	70,104,802
2012	70,363,628
2013	68,017,029
2014	11,504,209
Total	**1,063,396,165**

3. Surface Disposal Operations

Agency-permitted s umps are used to dispose of wastewater during upset conditions through a combination of evaporation and percolation. One lined sump is located on alluvial sediments, and therest areon the Tulare Formation (Exhibit 33; Exhibit 15). Active sumps are operated under Regional Water Quality Control Board Waste Discharge Requirements Order #58-491. A table summarizing the locations, types, and s tatus of the sumps is provided in Table 8.

As discussed in Section G, a regional groundwater study was done to investigate the geologic and hydrogeologic conditions in western Kern County and the impact of oilfield operations on groundwater quality (Western Oi l and Gas Association, 1983) . The 1983 study indicated that: "…natural salts have been concentrated in some specific areas where deep percolation from agricultural production and/or water disposal has provided the fluid path to groundwater " and that "…oilfield waste disposal is a likely contributor where concentrations of boron, nitrate and chloride are found."

Table 8

Sump Data within the Area of Review

Location	Active	Inactive	Closed
Section 7R	2 pigging sumps	1	
Section 8R	1 pigging sump		
Section 9R	1 pigging sump		
Section 15R	1 pigging sump		
Section 18R			1
Section 26R			2
Section 27R		2	
Section 24Z		6	
Section 26Z		1	7
Section 27S		1	
Section 34S	1 pigging sump		
Section 35S		1	
Section 1G			1
Section 7G		3	
Section 9G		1	
Section 10G	4	2	
Section 18G	1 lined		5
Total	**11**	**18**	**16**

K. OTHER INFORMATION RELATIVE TO AQUIFER

1. Distance to Existing Towns

The Tulare aquifer exemption area is located on the southwestern side of the San Joaquin Valley in a remote, unincorporated part of Kern County. The five nearest surrounding towns are:

- Buttonwillow: 5 miles to the north
- Tupman: 0.5 miles to the northeast
- Dustin Acres: 0.5 miles to the south
- Derby Acres: 3.5 miles to the southwest
- McKittrick: 2.5 miles to the west

Other towns within the area of review are shown in Exhibit 1.

2. Ownership and Types of Land Use within the Area of Review

Land within the Tulare aquifer exemption area is owned both privately and federal ly (Exhibit 34). The Tulare aquifer exemption area is zoned as Exclusive Agriculture (A), Limited Agriculture (A-1), Medium Industrial Precise Development (M-2 PD), and Estate Residential Suburban Mobile Home [E (1) RS MH] (Exhibit 35; Kern County Planning Department, 2014). Growing and harvesting crops as well as breeding and raising animals are allowed in the A and A-1 zones. The purpose of the A District is to designate areas suitable for agricultural uses and prevent incompatible uses from encroaching and prematurely converting these lands to non-agricultural usage. Land zoned as A-1 is designated as suitable for a combination of estate-type residential development, agricultural uses, and other compatible uses. A map of agricultural land usage in the Tulare aquifer exemption area is provided in Exhibit 36.

A review of a Kern County Geographic Information System (GIS) map of the Tulare aquifer exemption area indicates that land is mostly undeveloped and used primarily for oil field operations (Exhibit 37). There does not appear to be any irrigated farmland within the area of review, except for a small corner of 13G.

3. Population and Water Usage

The Tulare aquifer exemption area lies entirely within the boundaries of the WKWD except for one area that is not part of the WKWD or any other local water district (Exhibit 38). The WKWD serves the cities of Taft and Maricopa as well as McKittrick, Ford City, and other Westside communities near the Tulare aquifer exemption area. It sells water to a permanent population of about 18,600, with about 7,400 service connections, of which about 7,000 are for domestic users. The area served by the WKWD covers about 300 square miles (Kern County Water Agency, 2011).

Total annual water use in the WKWD in 2010 was 24,729 acre-feet, or 216 gallons per capita per day, including significant quantities of water used by industries in the district (West Kern Water District, 2011). About 80 percent of the WKWD's water sales are to industry, and the remaining 20% are domestic water sales. It also supplies some water for landscaping and recreational use.

4. Availability of Alternate Surface and Groundwater Sources

The WKWD contracted with the KCWA in 1966 to deliver water from the SWP via the California Aqueduct. Since 2002, the WKWD has had a SWP entitlement of a maximum 31,500 acre-feet per year, with an additional 10,000 acre-feet per year under the interruptible SWP contract when high-flow water is available from the Delta. The high-flow water typically is purchased by the WKWD for its groundwater banking program.

The WKWD has two turnouts along the California Aqueduct but only uses one to deliver untreated water to industrial customers OEHI and La Paloma Generating Company, LLC (LPGC). A maximum of 6,500 acre-feet of water can be used by LPGC. However, because LPGC has historically used less than the maximum, the WKWD has been able to use the remainder for groundwater recharge or exchange with other entities. Except for the delivery of untreated water from the California Aqueduct to LPGC, surface water is not used directly by the WKWD as a domestic water supply source (West Kern Water District, 2011).

The majority of the WKWD's SWP water is received through an in-lieu groundwater pumping/groundwater banking exchange with the Buena Vista Water Storage District (BVWSD)[18]. The BVWSD receives water from the Kern River, the SWP, and local groundwater wells. The exchange between the BVWSD and the WKWD involves the BVWSD taking WKWD SWP water rather than producing groundwater from its wells. The WKWD then can either pump or bank the equivalent amount of SWP water used by the BVWSD. In wet years, when the BVWSD can meet its water demands from the Kern River, it does not have to take SWP water from the WKWD. Instead, the SWP water is delivered to the WKWD groundwater recharge area and credited to its banking program. Because the WKWD has historically needed less water than the SWP water exchanged with the BVWSD, it has banked any surplus water. For the period from 1977 to 2010, this surplus averaged 17,418 acre-feet per year. At the end of the 2010 water year, there was a total surplus of 208,157 acre-feet, including 31,483 acre-feet owed to the WKWD from other agencies (WKWD, 2011).

The WKWD's domestic water needs also are supplied by the South Well Field near Tupman, located about two miles northeast of the Elk Hills Tulare aquifer exemption area, and the new North Well Field, located about 4.5 miles to the north (Exhibit 1). The South Well Field and recharge ponds are located adjacent to the Kern Water Bank recharge area (Exhibit 1). Well depths in the Tupman well field range from 650 to 850 feet. The total peak production capacity is 99 acre-feet per day, but the maximum usage is 61 acre-feet per day (West Kern Water District, 2011).

Based on historical usage, the WKWD and the BVWSD entered into an agreement in 1965 that allows the WKWD to pump a maximum of 3,000 acre-feet annually from the Tupman well field. This water cannot be banked and is used preferentially in any given year. The WKWD is required to recharge the groundwater basin for amounts pumped in excess of 3,000 acre-feet annually. At the end of the 2010 water year, the WKWD had an estimated 176,674 acre-feet of banked water.

The WKWD also has undertaken a new recharge and recovery project, referred to as the North Well Field Project (Exhibit 1). Water production capacity is expected to increase from the current 55,000 acre-feet to 100,000 acre-feet. The WKWD's website provides the following discussion on the new well field (http://wkwd.org):

> "The latest development The WKWD's North Well Field Project involves the construction of a new well field located on the axis of the Kern River between

[18] The location of the BVWSD is shown on Exhibit 1.

Interstate 5 and the California Aqueduct, which encompasses roughly 1000 acres. It will allow the District more flexibility and reliability in the development of its water supplies. Historically, the District has been entirely dependent on a single well field location to meet its water demands. In recent years, groundwater levels have seen great declines due to increased pumping to make up for the reductions in our annual State Water Project water supplies, and this newly acquired North Well Field Location allows the District access to an additional 100,000 acre -foot block of stored groundwater underneath the project location. In addition, the project provides additional wells that allow for redundancy and flexibility in our water production operations. The first phase of the project involves the construction of water wells and pipelines and is scheduled to become operational by the end of 2011. A subsequent phase calls for additional pipelines that should further increase operational flexibility."

There is an additional operating agreement between the WKWD and the KWBA for pumping and recharge activities. An opportunity also exists for the WKWD to connect to three KWBA water wells, which were permitted for use by both the WKWD and the KWBA. This potential water transfer would be as much as 12,905 acre-feet.

As discussed in its 2010 Urban Water Management Plan, the WKWD's water needs in the Tulare aquifer exemption area were believed to be adequately served by existing and future sources for the following reasons:

- Current demand is well below production capacity;
- Since the 1970s, the WKWD's water needs have been less than the SWP supplies delivered via the exchange with the BVWSD;
- The WKWD has banked an average of 17,418 acre -feet of surplus water annually from 1977 to 2010;
- The new North Well Field is expected to nearly double production capacity in the WKWD;
- The WKWD did not believe that desalination of brackish water or groundwater was practical and has no current plans to pursue this method of treatment.

5. Geology, Including Any Unusual Conditions

The Elk Hills field is located within an area of the San Joaquin Basin which has only interior drainage and no appreciable surface or subsurface outflow The Kern River, which is the primary source of surface water and fresh groundwater in the area, drains to the southeast and terminates near the northeastern side of the Elk Hills field. Precipitation in the Elk Hills area averages about 5.8 inches annually, with an average pan evaporation rate of about 108 inches per year in the Buttonwillow area[19]. As a result, almost no groundwater from precipitation recharges groundwater, causing salts to become more concentrated over time and potentially resulting in high TDS concentrations.

Surface geologic mapping indicates that only Recent alluvium and Tulare Formation occur within the Elk Hills Tulare aquifer exemption area (Exhibit 15). With depth, groundwater comes into direct contact with the marine San Joaquin Formation, which causes the groundwater to become naturally more saline.

6. Aquifer Interconnection with Surface and Fresh Waters within the Area of Review

The Tulare aquifer exemption area lies within the Tulare Lake Hydrogeologic Basin, which is a closed, northwesterly-trending basin in the southern San Joaquin Valley. To the north and northeast of the Elk Hills field, the Kern River in the San Joaquin Valley is the primary source of groundwater recharge. Mounding occurs along the axis of the river and flattens laterally. Streams in the Temblor Range to the east of Elk Hills drain southeasterly toward Buttonwillow, which lies north of the Elk Hills field, and into the McKittrick Valley, which lies to the southwest. None of the ephemeral streams that drain the eastern slopes of the Temblors carry potable water because they cross marine sedimentary rocks from which high concentrations of TDS are acquired (Maher, 1975).

Within the Elk Hills field, ephemeral streams drain toward the San Joaquin, McKittrick, and Buena Vista valleys (Exhibit 2; Exhibit 15). There are no intermittent drainage courses in the Elk Hills field which meet the requirements for navigable waterways under Section 404 of the Clean Water Act. There are no known natural springs or other continuous sources of natural recharge within the Elk Hills field.

Aquifer interconnection between any surface water and Tulare groundwater within the area of review is unlikely because there are no known bodies of surface water or naturally-occurring fresh water[20] or springs within the area of review (Phillips, 1994; Exhibit 2; Exhibit 15; Exhibit 16; Exhibit 29).

The interconnection of the Tulare Formation with naturally-occurring fresh water in Elk Hills is believed to be unlikely because precipitation in this area averages only about 5.8 inches annually, with an average annual pan evaporation rate of about 108 inches in the Buttonwillow area[21]. Consequently, almost no groundwater from precipitation is available to recharge groundwater. Within the Tulare Formation, low-permeability silts, siltstones, clays, and claystones can separate sands and gravels and act as groundwater barriers between zones having distinctly different salinities as well as seals for petroleum

[19] Information Sheet on the Regional Water Quality Control Board website for Clean Harbors Buttonwillow, LLC.
[20] Defined as TDS <3,000 mg/l.
[21] Information Sheet on the Regional Water Quality Control Board website for Clean Harbors Buttonwillow, LLC.

accumulations. However, the degree of interconnection between the Tulare Formation along the northeastern flank of the Elk Hills Tulare aquifer exemption area and shallow, fresh groundwater, especially for the WKWD well fields that are located a minimum of two miles to the northeast and 4.5 miles north, is not well understood. Consequently, the northeastern flank area have been excluded from this document.

Within the 26R area, a leak from a utility water line in section 26, which has since been taken out of service, is believed to have been the source of non-naturally occurring fresh water in the unsaturated upper Tulare zone (Exhibit 39). However, the unsaturated upper Tulare zone is not part of the aquifer exemption interval.

L. ECONOMIC EVALUATION OF TREATING MCKITTRICK AREA GROUNDWATER FOR DRINKING WATER

On behalf of LPGC, Kennedy/Jenks Consultants prepared a technical and economic feasibility evaluation of treating Tulare groundwater in the McKittrick area for use as drinking water. The LPGC is located in the Asphalto field, which is adjacent to the Elk Hills field. The purpose of the report titled, "Evaluation of Economic Feasibility of Treating McKittrick Area Groundwater for Use as Drinking Water," and dated March 2002, was to evaluate whether McKittrick area groundwater could be designated as Class III water, defined as groundwater not a source of drinking water. Groundwater can be designated as Class III water if there is:

> "Contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot be cleaned up using treatment methods reasonably employed in public water-supply systems."

The Class III designation is based on a socioeconomic evaluation of the benefits and costs of groundwater protection. The economic infeasibility of treating groundwater for drinking water is assessed by a comparison of the cost to treat McKittrick groundwater to the current potable water treatment cost in the area. In the Kennedy/Jenks evaluation, groundwater would be classified as Class III if the cost of developing, treating, and delivering the water is: 1) more than 0.4% of the median annual income per household in the area, 2) exceeds 100% of the current annual water treatment rate, or 3) exceeds the ninetieth percentile economic untreatability threshold. The economic feasibility study had the following findings (Exhibit 40):

- A sample of McKittrick area groundwater had high concentrations of TDS (6,100 mg/l), boron (21 mg/l), sulfate (1,200 mg/l), chloride (1,600 mg/l), and hardness (1,100 mg/l).
- Tulare groundwater in the McKittrick area cannot be treated by treatment technologies by methods employed in public water systems or methods known to be used in a limited number of cases.
- Using reverse osmosis (RO) technology, McKittrick area Tulare groundwater treatment was estimated to cost $34,500 per acre-foot for a system with a design flow rate of 165,000

gallons per day (GPD) and $5,800 per acre-foot for a system with a rate of 2.85 million gallons per day (MGPD). Potable water treatment in the McKittrick area is $500 per acre-foot. The small and large RO treatment systems would be about 70 and 10 times, respectively, more than the current potable water source.

- For the 165,000 GPD and 2.85 MGPD systems, the cost to treat McKittrick area groundwater was about 75% and 13%, respectively, of the annual McKittrick area household income. These costs exceeded the EPA's Class III guideline that the per-household share of treatment cost should not be more than 0.4% of the area per-household income.
- A second EPA economic threshold is that increase in annual water cost per household should not exceed 100%. In the Kennedy/Jenks study, the annual water cost per average household in the McKittrick area was $255. The increase in annual water cost per household to treat Tulare groundwater in the McKittrick area was $17,345, or about 6,800% increase, for the 165,000 GPD system and $2,695, or a 1,060% increase, for the 2.85 MGPD system. Because costs for both systems are significantly greater than the EPA's economic criteria of no more than a 100% increase, the economic criteria for the Tulare groundwater in the McKittrick area being classified as Class III groundwater, or groundwater not a source of drinking water, was met.
- Because the two EPA criteria for economic infeasibility were met, it was concluded that McKittrick area groundwater should be designated as Class III, or groundwater not a source of drinking water.

The June 1998 EPA guidelines for classifying groundwater also have an economic untreatability threshold based on the annualized total costs of replacement or hypothetical systems that exceed the costs faced by 90% of community water-supply system users (U.S. Environmental Protection Agency, 1988). This ninetieth percentile economic untreatability threshold is calculated using the following equation:

Threshold = [(-200.255) x Log (Size)] + 1,248.727

Where:

Threshold = Threshold cost in dollars per household per year

Size = User population, in individuals

For a McKittrick area population size of 22,000:

Threshold = [(-200.255) x Log (22,000)] + 1,248.727

= $379.14

The Kennedy/Jenks study calculated increases in costs of $17,345 per household for the 165,000 GPD small system and $2,695 per household for the 2.85 MGPD large system are significantly in excess of the ninetieth percentile economic untreatability threshold of $379.14 per-household by a factor of about 46 and 7 times, respectively. Because this EPA economic untreatability guideline also was met, McKittrick area groundwater was demonstrated to be classified as Class III, or groundwater not a source of drinking water.

Mr. Fernando Granizo, a n OEHI facilities engineer , reviewed the Kennedy/Jenks study to determine if water treatment costs would still be relevant SJEC provided updated information on median household income, number of persons per household, per capita water usage, and households/population served. OEHI concluded that the economics of the earlier study were relatively comparable and that the cost to treat Tulare groundwater in the Elk Hills field for use as drinking water would still be economically infeasible.

Tulare groundwater in the Elk Hills field contains high concentrations of TDS, iron, chloride, sulfate, boron, and sodium, which are comparable to the McKittrick area groundwater in the Kennedy/Jenks report (Table 9). However, it also locally contains hydrocarbons and strontium, as well as a high concentration of lead, all of which would need to be treated before being used as drinking water. These additional sources of contamination in Elk Hills Tulare groundwater, as discussed in Sections G, I, and J of this document, would increase treatment costs and, consequently, increase the economic infeasibility to treat it for use as drinking water. For this reason, the Tulare groundwater in the Elk Hills field should be considered as Class III groundwater. It is believed that the Tulare groundwater has a low resource value except for use in Class I non-hazardous and Class II UIC injection operations.

Table 9

Comparison of Tulare Groundwater in the Elk Hills Field and the McKittrick Area

Constituent	Tulare Groundwater McKittrick Area (mg/l)*	Tulare Groundwater Elk Hills Field (mg/l)
Lead	<0.05	0.0208
Selenium	<0.05	Below Amnicola claystone: 0.720
Iron	0.56	<0.1 to 37
TDS	6,100	4,150 to 8,720 Below Amnicola: 7,168 to 20,000
Chloride	1,600	1,000 to 6,049.5
Sulfate	1,200	840 to 1,800
Boron	21	3.7 to 10.0
Sodium	1,300	856 to 1,800
Strontium	Not analyzed	5.0 to 6.8
Hydrocarbons	Not analyzed	Variable

* See Exhibit 40.

M. CONCLUSIONS

- The WKWD, the local water district within the area of review, has declared that the Tulare Formation in the Elk Hills aquifer exemption area does not currently serve as a source of drinking water and will not reasonably be expected to supply a public water system.
- The Tulare Formation in the Elk Hills field has been referred to and treated as an exempt aquifer by the EPA. On February 21, 2001, the EPA authorized Class I non-hazardous injection in two Tulare disposal wells for Elk Hills Power under UIC Permit #CA200002. In addressing public comments received during the review process, the EPA wrote that it "… had made the determination that the Tulare Formation within the Area of Review is an exempt aquifer." The area of review for the Elk Hills Power UIC permit was in section 18G, which has Tulare groundwater that is comparable in its poor quality to other areas of the Elk Hills field. The UIC permit was modified on June 3, 2004, to authorize two additional Tulare injection wells. Nearly 35 million bbls of industrial, nonhazardous fluids produced during the operation of the Elk Hills Power Plant were injected into the Tulare Formation in the southern area of the Elk Hills field.
- The Tulare Formation within the Elk Hills field has been regularly described and treated by the DOGGR as an exempt aquifer for Class II UIC injection. Two Tulare Class II wastewater disposal projects and several project expansions in the Elk Hills field have been approved by the DOGGR. Since July 1981, more than 1.06 billion bbls of produced water have been injected into the Tulare Formation using more than 130 Tulare wastewater disposal wells.
- The Tulare Formation has been used since July 1981 as an injection zone for produced water. Although this post-dated the submittal of the DOGGR's Primacy Application in April 1981, it was 14 months before the EPA granted final approval of this primacy in September 29, 1982. In this 14-month interim, the Tulare Formation in the Elk Hills field was not included in the Primacy Application. As a result, it was not designated as an exempt aquifer based on being a non-hydrocarbon producing zone used for wastewater disposal when the DOGGR-EPA MOA was approved in September 1982.
- Oil has been produced from the Tulare Formation in the Elk Hills field since 1975 and was documented as a March 1975 discovery in in the DOGGR's 1998 version of *California Oil and Gas Fields*. Although this pre-dates the DOGGR's April 1981 Primacy Application, the Tulare Formation in the Elk Hills field was not included as an exempt aquifer based on hydrocarbon production when the DOGGR-EPA MOA was approved in September 1982.
- TDS concentrations in Tulare groundwater within the area of review are more than 3,000 mg/l and can range up to 20,000 mg/l below the Amnicola clay stone in areas of the Elk Hills field. Where TDS concentrations exceed 10,000 mg/l, the Tulare Formation does not meet the definition of a protected USDW and therefore is an exempt aquifer. High concentrations of lead, iron, TDS, chloride, sulfate, boron, and sodium in Tulare groundwater result mainly from naturally-occurring sources and its use a disposal zone in Class II UIC injection operations.

- Tulare groundwater is unfit for municipal and agricultural uses because it has: 1) a lead concentration that exceeds the California Title 22 primary MCL for drinking water; 2) concentrations of TDS, chloride, and sulfate in excess of secondary drinking water standards; 3) boron, strontium, and sodium concentrations that are significantly higher than regulatory thresholds for human health, agricultural uses, and/or livestock watering; 4) petroleum in local areas of the field; and 5) iron concentrations that are variable but can occur in excess of the secondary MCL for drinking water.
- The EPA criteria for economic infeasibility of treating Tulare groundwater in the McKittrick area for use as drinking water were met because treatment costs: 1) were more than 0.4% of the median annual income per household in the area; 2) exceeded 100% of the current annual water rate; and 3) were greater than the ninetieth percentile economic untreatability threshold of $379.14 per household annually.
- The Tulare groundwater in the Elk Hills field can be characterized as Class III, or groundwater not a source of drinking water, because: 1) its TDS concentrations are more than 3,000 mg/l and less than 10,000 mg/l; 2) the EPA's economic infeasibility criteria to treat McKittrick area groundwater for use as drinking water are met: and 3) Tulare groundwater in the Elk Hills area is at least as poor, and likely poorer, in quality as the economically untreatable Tulare groundwater in the McKittrick area.
- There are no known domestic water wells within the area of review based on searches of water well databases, review of well records, and site reconnaissance.
- According to its 1997 *Groundwater Management Plan*, the WKWD believed that: 1) its supplies were adequate to meet peak daily demands and future needs; and 2) despite potential shortages in SWP deliveries, it did not need to pursue additional sources of water.
- The Tulare groundwater in the Elk Hills field has low resource value except for its use in Class I non-hazardous and Class II UIC injection operations.
- Hydraulic fracturing will not be required as part of Tulare development in the Elk Hills field.

Respectfully submitted,

REGISTERED GEOLOGIST
DONNA M. THOMPSON
STATE OF CALIFORNIA

Donna M. Thompson

California Professional Geologist No. 5347
California Certified Hydrogeologist No. HG 241

Please note that all geologic maps, cross-sections, discussion of salinity calculations, and salinity calculation exhibits and some discussion of groundwater characterization in this document were prepared by Mr. Stephen A. Reid, California-licensed Professional Geologist No. 3876.

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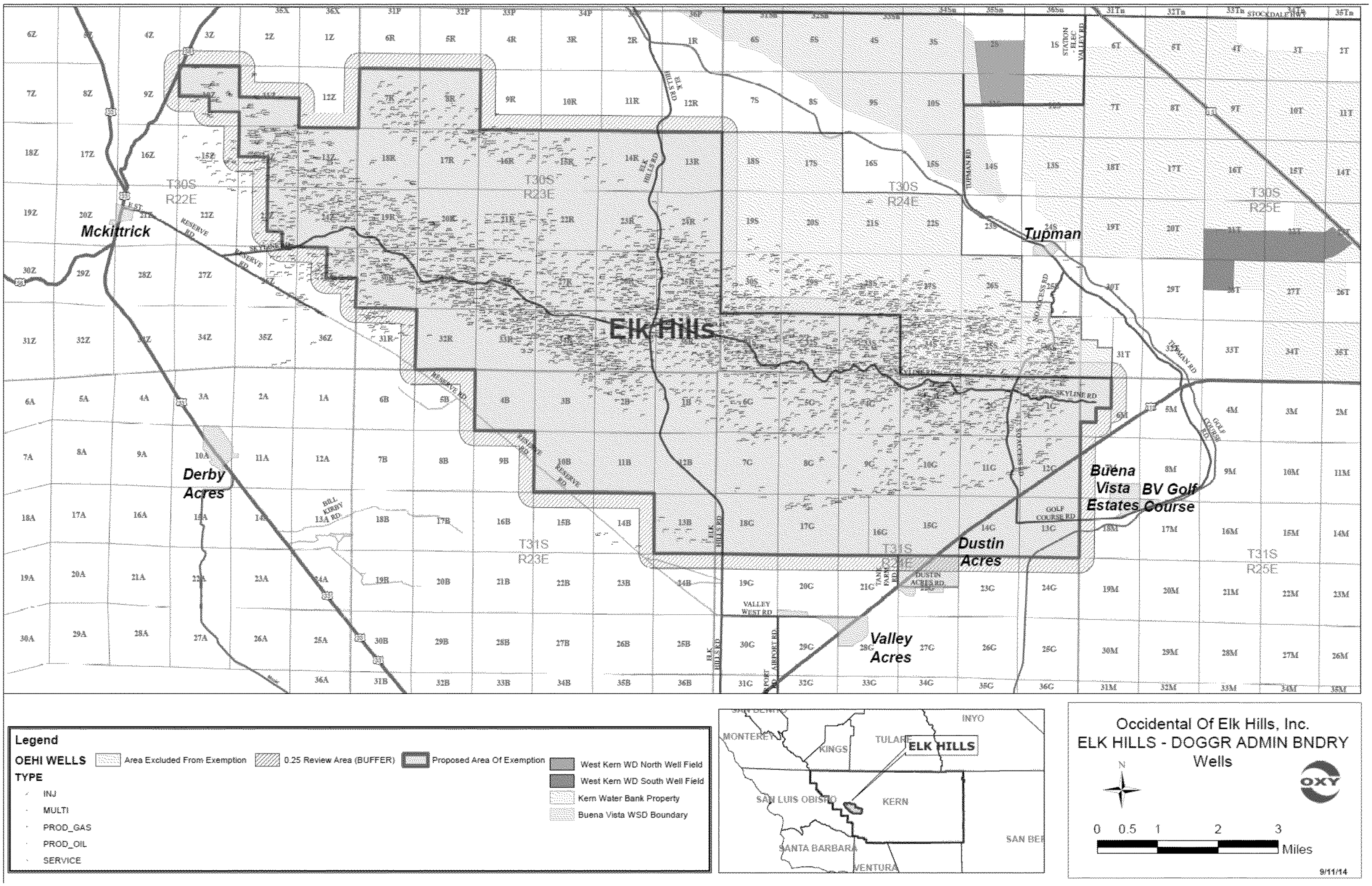
EXHIBITS

Exhibit 1

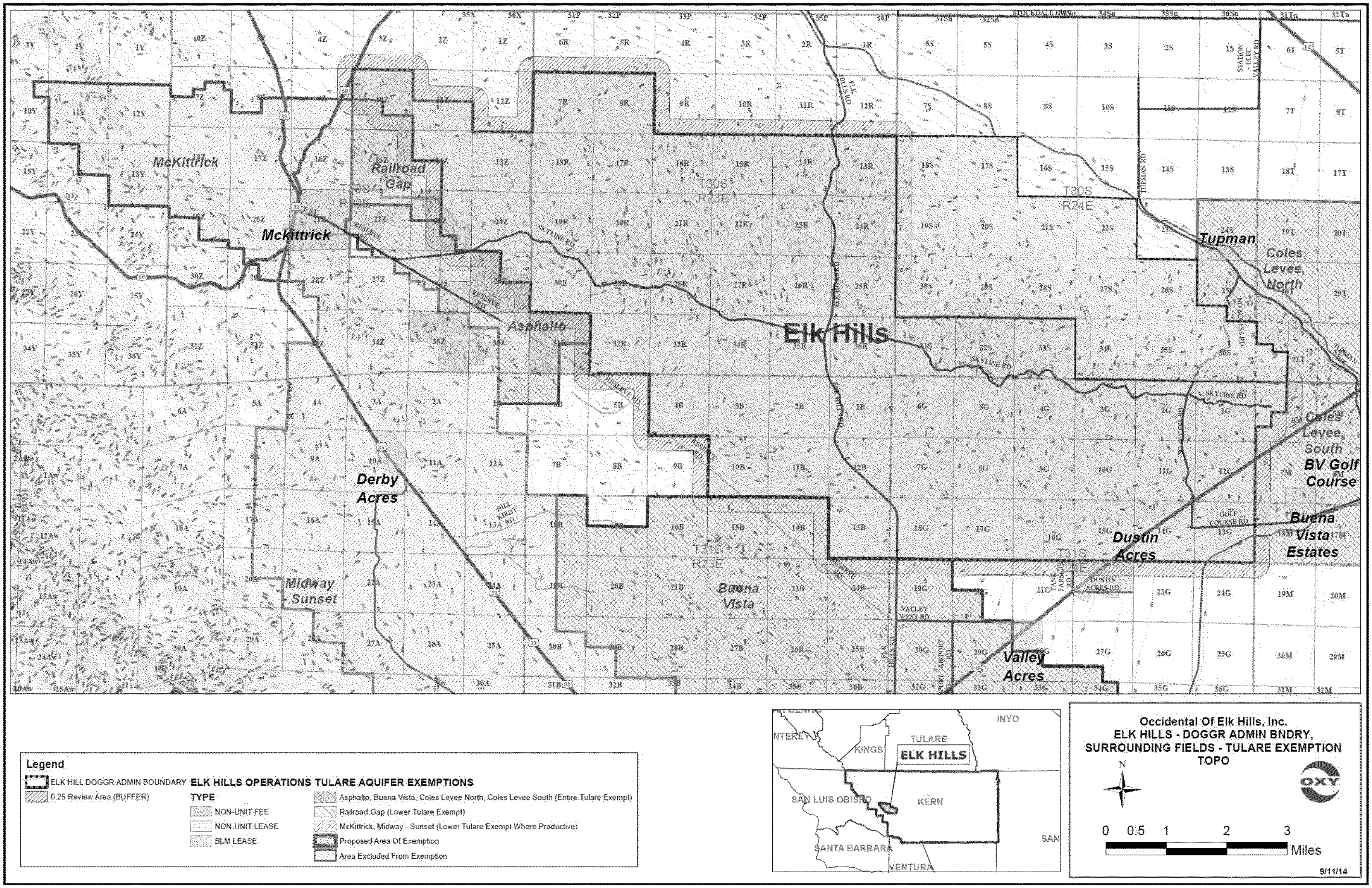
Map of Elk Hills Tulare Aquifer Exemption Area and Well Locations



Elk Hills Tulare aquifer exemption area showing locations and types of wells within the area of review

Exhibit 2

Topographic Map



Topographic map of the Elk Hills field showing existing Tulare aquifer exemptions in all or portions of the surrounding oil fields

Exhibit 3

Declaration from Local Water Agency

West Kern water district

September 19, 2014

Mr. Bill Penderel
Associate Oil & Gas Engineer
Division of Oil, Gas, and Geothermal Resources
UIC Program
Via Email

RE: OCCIDENTAL ELK HILL, INC. TULARE AQUIFER EXEMPTION DOCUMENT ELK HILLS FIELD

Dear Mr. Penderel,

On May 15, 2014 San Joaquin Energy Consultants (SJEC) on behalf of Occidental of Elk Hills, Inc., (OEHI) contacted West Kern Water District (WKWD), stating they were in the process of preparing an application in the Elk Hills oilfield for an aquifer exemption for the Tulare Formation in portions of the Elk Hills project to allow Class II UIC Injection Operations, within the WKWD service area,.

SJEC requested WKWD provide the Division of Oil, Gas and Geothermal Resources a letter stating the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system within the project area as shown in the application map Exhibit 1-1 (and attached).

WKWD Staff and the District's consulting hydrogeologist have reviewed water quality data and various reports provided by SJEC within the project area and concluded the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system in the project area shown on the application map.

On September 15, 2014 the West Kern Water District – Board of Directors authorize Staff to issue a letter to the Division of Oil, Gas and Geothermal Resources stating the Tulare aquifer does not currently serve as a source of drinking water, and it would not reasonably be expected to supply a public water system in the project area as shown on the application map Exhibit 1-1.

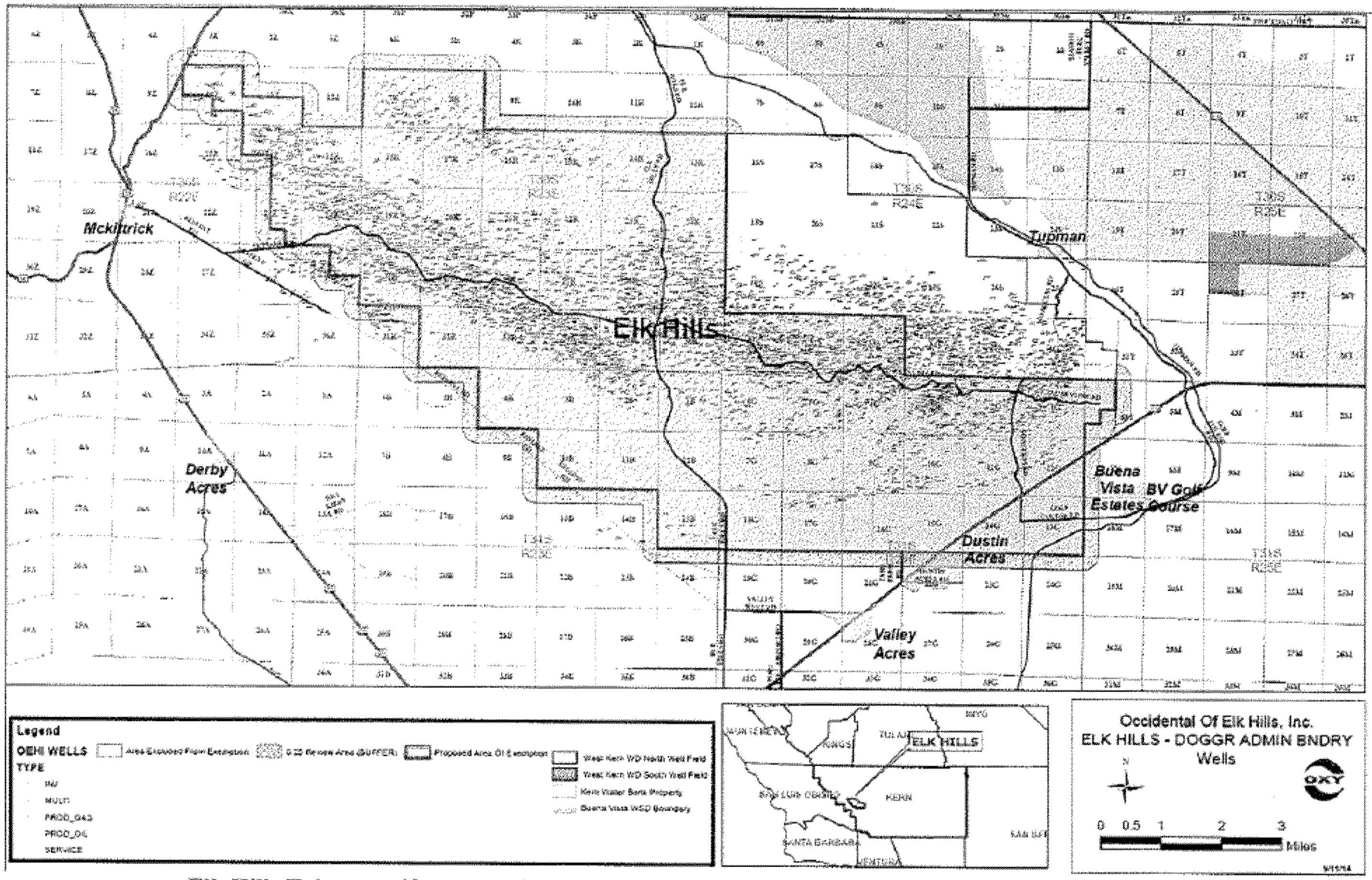
Should you require further correspondence regarding this subject please contact JD Bramlet of my Staff at (661) 763-3151.

Sincerely,

Harry O. Starkey
General Manager

West Kern Water District · 800 Kern St., P. O. Box 1105 · Taft, California 93268-1105 · 661 763-3151 · FAX 661 765-4271

Declaration from the West Kern Water District



Elk Hills Tulare aquifer exemption area showing locations and types of wells within the area of review

Declaration from the West Kern Water District

Exhibit 4

Excerpts from the EPA Letter Dated May 17, 1985

RECEIVED
JUN 19 1985
DIVISION OF OIL & GAS
BAKERSFIELD

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

17 MAY 1985

Mr. Tom Cornwell
Western Oil and Gas Association
727 West 7th Street
Los Angeles, CA 90017

Dear Mr. Cornwell:

The staffs of EPA-Region 9 and the California Division of Oil and Gas (CDOG) have been meeting with members of the Western Oil and Gas Association (WOGA), the California Independent Producers Association (CAIPA), and the Independent Oil Producers Agency (IOPA) to determine how wells injecting specific types of oil field fluids will be regulated under the Underground Injection Control (UIC) program in California. The purpose of this letter is to clarify:

1. how wells injecting filter backwash (diatomaceous earth or multi-media filter backwash), water softener regeneration brine, or air scrubber waste will be classified and regulated under the UIC program in California;

2. the requirements, especially the regulatory deadlines for the submission of permit applications and inventory information for existing wells, for different classes of wells; and

3. which formations identified by CDOG in its primacy application were verified as Underground Sources of Drinking Water (USDW) and exempted and which formations were determined not to be USDWs and did not need to be exempted when primacy for CDOG was approved.

In general, the classification and regulation scheme for wells injecting filter backwash, water softener regeneration brine, or air scrubber wastes under the UIC program in California is:

- wells which inject filter backwash are Class II wells and are regulated by CDOG;

- wells which inject either water softener regeneration brine or air scrubber wastes for the purpose of enhancing oil or natural gas recovery are Class II wells and are regulated by CDOG; and

- wells which inject either water softener regeneration brine

Page 1 of the 5/17/85 EPA Letter

or air scrubber wastes for disposal are either Class I or Class V wells and are regulated by EPA.

Attachment 1 provides: a precise statement about these well classifications; a brief description of each of the fluids being injected; clarification of how wells used to inject commingled fluids will be regulated; and a diagram which outlines how wells injecting the different types of fluids will be regulated and by whom in California.

Some, but not all, of the relevant requirements for Class I, II, and III wells under the UIC program implemented in California are:

- Class I wells - for existing wells (wells in operation prior to June 25, 1984) complete permit applications must be submitted to EPA by June 25, 1985 (40 CFR 144.31[c][1] and 147.251[B])
  - for new wells, permits must be in effect prior to any construction (40 CFR 144.11)
- Class II wells - CDOG has been delegated this portion of the UIC program and regulates this class of wells
- Class V wells - for existing wells, a completed inventory form and the required additional information must be submitted to EPA by June 25, 1985 (40 CFR 144.26[d][1] and 147.251[B])
  - for new wells, a complete inventory form and the required additional information should be submitted to EPA prior to construction.

Complete permit applications for existing Class I wells must be submitted to EPA by June 25, 1985. Considering the delays in classifying wells injecting filter backwash, water softener regeneration brine, or air scrubbing waste, allowances may be made for the submission of additional clarifying information after June 25, 1985. However, allowances can only be considered if an application has been been submitted by June 25, 1985 and if the application represents a reasonable and substantial effort toward a complete permit application.

Attachment 2 provides the exact definitions for the different classes of wells and other pertinent definitions in the UIC program. Attachment 3 and 4 are copies of the permit application and Class V Inventory Notification, respectively.

There appears to be some confusion about which formations in oil and gas fields are USDWs and which formations in oil and gas fields are not USDWs under the UIC program. When CDOG submitted

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its application for the Class II portion of the UIC program, it submitted information about a large number of formations in oil fields to be considered for aquifer exemptions. These included formations which produced oil or gas and formations which did not produce any oil or gas. After reviewing the information from CDOG supporting the aquifer exemptions requests, all formations which were USDWs and produced oil or gas were exempted but only some of the formations which did not produce any oil or gas were granted aquifer exemptions. These latter formations were not exempted because the supporting information demonstrated that they were not USDWs as defined by the UIC program. They yielded water which had a Total Dissolved Solids concentration greater than 10,000 milligrams per liter.

Maps showing the lateral extent of any formation which was exempted can be found in California Oil and Gas Fields (Volumes I, II, and III) and Appendix B of CDOG's primacy application. They are available for review at the EPA office in San Francisco or at any of the CDOG district offices. A list of those formations, which did not produce any oil or gas and were considered for aquifer exemptions, is provided as Attachment 5. A list of those formations, which did not produce any oil or gas and which were USDWs and exempted, is provided as Attachment 6.

I would like to take this opportunity to thank those of your members who met and worked with us to clarify these points in the UIC program. If you have any further questions or need other points of clarification, please call Pete Uribe of my staff at (415) 974-7285.

Sincerely,

for Frank M. Covington, Director
Water Management Division

ATTACHMENTS

1	Well Classification and Regulation Scheme	(3 pages)
2	UIC Definitions	(3 pages)
3	Permit Application	(10 pages)
4	Class V Inventory Notification	(7 pages)
5	List of Formations Considered for Exemption	(3 pages)
6	List of Formations Exempted	(1 page)

cc: M.G. Mefferd, CDOG
J. B. Braden, CAIPA
Les Clark, IOPA
Jim Cornelius, SWRCB
Bill Pfister, CVRWQCB
John Atcheson, EPA HQ

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NONHYDROCARBON-PRODUCING ZONE INJECTION DATA

DIST.	FIELD	FORMATION & ZONE	TDS OF ZONE WATER PRIOR TO INJECTION	TDS OF INJECTED WATER	VOLUME INJECTED (Barrels)	INJECTI STARTE
1	Belmont Offshore	Repetto	30,800			
1	Huntington Beach	Lakewood				
		Alpha 1	37,200			
		Alpha 2	12,500			
1	Sawtelle	Puente	25,500			
1	Seal Beach	Repetto	29,700			
		Recent Sands	30,200			
1	Wilmington	Gaspur	28,200			
1	"	River Gravels	30,800			
2	Ramona	Pico	5,000	15,300 ppm NaCl	1,793,000	6/51
2	South Tapo Canyon	Pico	1,900 ppm NaCl	600 ppm NaCl	1,903,000	1/48
2	Oat Mountain	Undiff.	4,800	23,800 ppm NaCl	91,000	4/56
2	Simi	Sespe	4,300	25,500 ppm NaCl	695,000	6/48
3	Guadalupe	Knoxville	30,500			
3	Lompoc	Lospe	119,000			
3	Lompoc	Knoxville	30,500			
3	Russell Ranch	Branch Canyon	13,000			
3	San Ardo	Santa Margarita	3,700	5,600	81,800,000	11/66
3	"	Monterey "D" Sand	4,600	5,600	13,795,000	7/59
3	"	Monterey "E" Sand	6,400	5,600	6,057,000	3/68
3	Santa Maria Valley	Lospe-Franciscan	119,000			
3	Monroe Swell	Santa Margarita	3,700 ppm NaCl	9,600	?	1981
3	Point Conception	Camino Cielo	26,200			
3	Guadalupe	Franciscan	30,500			
4	Bellevue	Etchegoin	26,500 (Analysis from adjacent field)			
4	Bellevue, West	Tulare	12,000*			
4	"	Etchegoin	26,500 (Analysis from adjacent field)			
4	Blackwell's Corner	Tumey	2,100 -2,600*	29,000 ppm NaCl	400,000	5/75
4	Buena Vista	Tulare	9,200	5,300-36,500	50,798,000	11/72
4	Cal Canal	Tulare-San Joaquin	Excess of 10,000*	22,000	537,000	5/79
4	Canfield Ranch	Etchegoin	≈12,800-26,500 (Analysis from adjacent fields)			

*"ψ" log calculation

17 MAY 198

Attachment 5
Page 1 of 3

Attachment 5, Page 1, of the 5/17/85 EPA Letter

DIST.	FIELD	FORMATION & ZONE	TDS OF ZONE WATER PRIOR TO INJECTION	TDS OF INJECTED WATER	VOLUME INJECTED (Barrels)	INJECT STARTE
4	North Coles Levee	Tulare	12,900			
4	"	San Joaquin	40,000-45,600			
4	"	Etchegoin	30,100			
4	South Coles Levee	Tulare	12,000-13,300			
4	"	San Joaquin	12,000-16,900			
4	Greeley	Etchegoin	26,500			
4	Kern Bluff	Kern River	≈ 400- 900 (From Kern River Field)	600	551,500	7/80
4	"	Vedder	≈ 7,800-16,100	" 11,700-213,000	4,099,000	3/80
4	Kern Front	Santa Margarita	2,300	1,100		9/75
4	Kern River	Chanac	238- 925	374- 865	1,071,000	6/77
4	"	Santa Margarita	600- 2,600	475- 16,200	154,994,000	9/73
4	"	Vedder	7,800-16,200		33,204,000	
4	Lakeside	San Joaquin	21,500			
4	Los Lobos	Tulare	33,300*			
4	Midway-Sunset	Alluvium	No water	3,600- 25,700	22,632,000	7/59
4	Mount Poso	Walker	2,800*	830- 1,440	3,681,000	9/75
4	Mountain View	Kern River	4,660*	1,200- 3,800	889,000	12/65
4	Pleito	Chanac & Kern River	7,900-11,800	12,800-30,800		8/74
4	Poso Creek	Vedder	12,500			
4	Rio Viejo	San Joaquin	21,000*			
4	Rosedale	Etchegoin	26,500 (Analysis from adjacent field)			
4	Round Mountain	Olcese	2,700	1,337- 1,965	29,797,000	7/74
4	"	Walker	1,930	1,600-2,100	203,319,000	8/72
4	Seventh Standard	Etchegoin	17,100-30,000 (NaCl only)			
4	Strand	Etchegoin	8,600 (NaCl only)		1,195,000	7/62
				16,500-25,600 (NaCl only)		
4	"	San Joaquin	33,400			
4	Ten Section	San Joaquin	12,900			
5	Burrel	Santa Margarita	35,000 (Analysis from Helm field)			
5	"	Tulare-Kern River	20,500 (Analysis from S.E. Burrel field)			
5	Southeast Burrel	Tulare-Kern River	20,500			
5	Coalinga	Santa Margarita	8,244	3,100- 3,500	(145,000,000	2/63
5	"	Etchegoin-Jacalitos	2,650- 2,900	2,650-2,700	(	2/63
5	Gill Ranch Gas	Zilch	14,500			

*"E" log calculation

Attachment C Page 2 of 3

Attachment 5, Page 2, of the 5/17/85 EPA Letter

Attachment 2

Exempted 1425 Demonstration Aquifers

All oil and gas producing aquifers identified in Volumes I, II, and III of the California Oil and Gas Fields submitted in the 1425 Demonstration dated April 20, 1981 are exempted.

In addition, the following aquifers are also exempted.

DISTRICT	FIELD	FORMATION/ZONE
2	Ramona	Pico
2	Oat Mountain	Undiff.
2	South Tapo Canyon	Pico
2	Simi	Sespe
2	San Ardo	Santa Margarita
3	San Ardo	Monterey "D" Sand
3	San Ardo	Monterey "E" Sand
3	Monroe Swell	Santa Margarita
4	Blackwell's Corner	Tumey
4	Kern Bluff	Kern River
4	Kern Front	Santa Margarita
4	Kern River	Chanac
4	Kern River	Santa Margarita
4	Mount Poso	Walker
4	Round Mountain	Olcese
4	Round Mountain	Walker
4	Buena Vista	Tulare
4	Kern Bluff	Vedder
4	Kern River	Vedder*
4	Mountain View	Kern River
4	Pleito	Chanac
4	Pleito	Kern River
4	Poso Creek	Santa Margarita
5	Coalinga	Santa Margarita
5	Coalinga	Etchegoin-Jacalitos
5	Guijarral Hills	Etchegoin-Jacalitos*
5	Helm	Tulare-Kern River
5	Riverdale	Pliocene
5	Turk Anticline	San Joaquin
6	Sutter Buttes Gas	Kione*
6	Bunker Gas	Undiff.
6	Wild Goose	Undiff.

*Oil and/or gas producing

Attachment 6 of the 5/17/85 EPA Letter

Exhibit 5

Index Map of Oil Fields

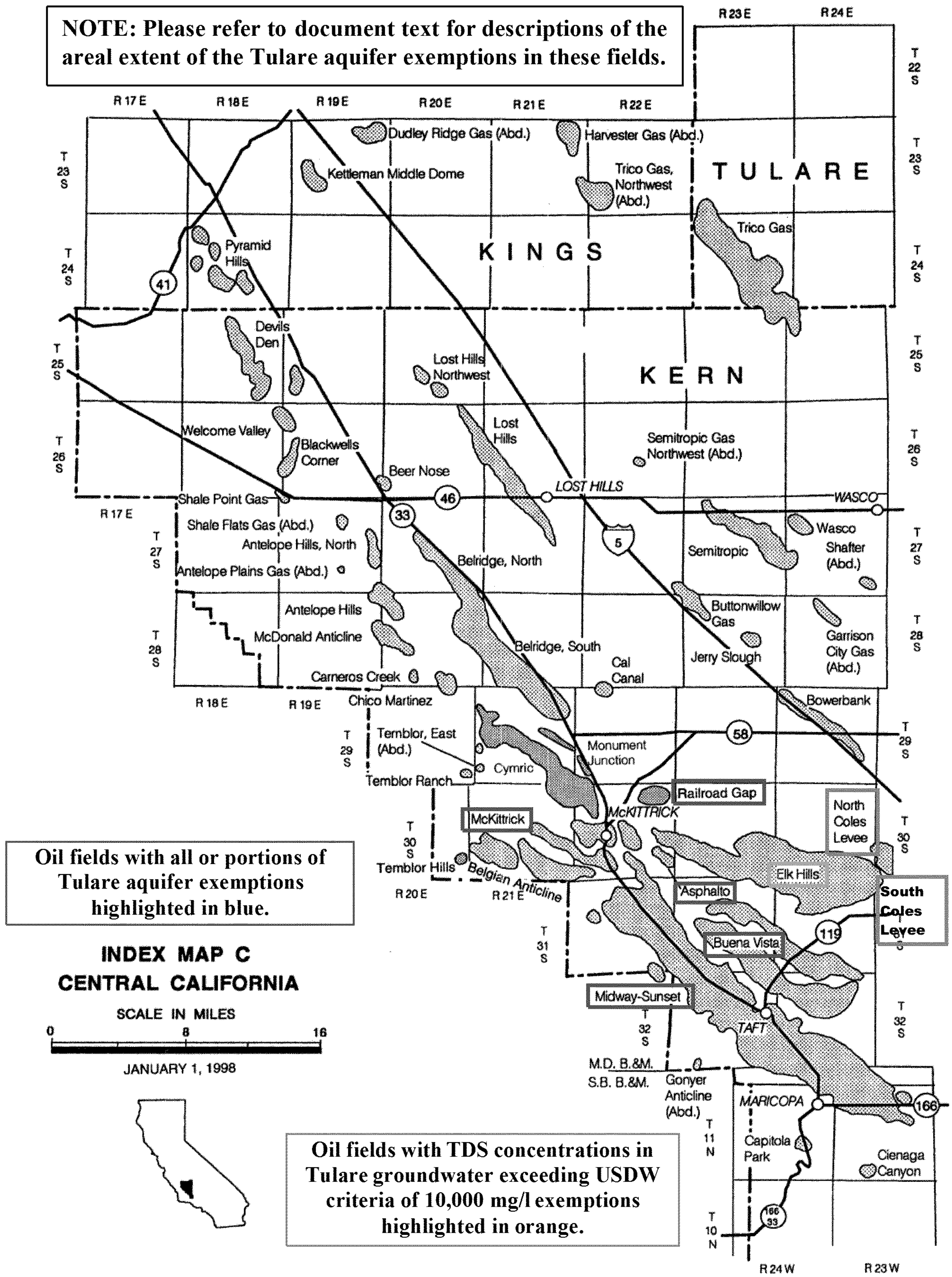
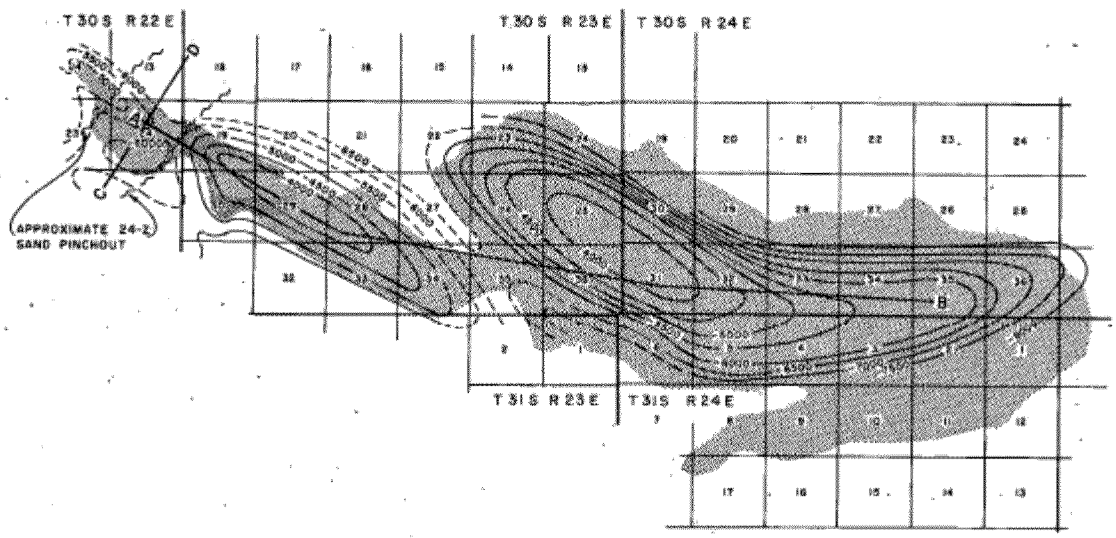

NOTE: Please refer to document text for descriptions of the areal extent of the Tulare aquifer exemptions in these fields.
Oil fields with all or portions of Tulare aquifer exemptions highlighted in blue.
Oil fields with TDS concentrations in Tulare groundwater exceeding USDW criteria of 10,000 mg/l exemptions highlighted in orange.
INDEX MAP C
CENTRAL CALIFORNIA
SCALE IN MILES
0
8
16
JANUARY 1, 1998
TULARE
KINGS
KERN
R 17 E
R 18 E
R 19 E
R 20 E
R 21 E
R 22 E
R 23 E
R 24 E
R 24 W
R 23 W
Dudley Ridge Gas (Abd.)
Harvester Gas (Abd.)
Kettleman Middle Dome
Trico Gas, Northwest (Abd.)
Trico Gas
Pyramid Hills
Devils Den
Lost Hills Northwest
Lost Hills
Welcome Valley
Blackwells Corner
Beer Nose
Semitropic Gas Northwest (Abd.)
LOST HILLS
WASCO
Shale Point Gas
Shale Flats Gas (Abd.)
Antelope Hills, North
Antelope Plains Gas (Abd.)
Belridge, North
Semitropic
Wasco
Shafter (Abd.)
Antelope Hills
McDonald Anticline
Buttonwillow Gas
Garrison City Gas (Abd.)
Belridge, South
Cal Canal
Jerry Slough
Carneros Creek
Chico Martinez
Bowerbank
Temblor, East (Abd.)
Monument Junction
Cymric
Temblor Ranch
Railroad Gap
McKITTRICK
McKittrick
North Coles Levee
Temblor Hills
Belgian Anticline
Elk Hills
Asphalto
South Coles Levee
Buena Vista
Midway-Sunset
TAFT
M.D. B.&M.
S.B. B.&M.
Gonyer Anticline (Abd.)
MARICOPA
Capitola Park
Cienaga Canyon

Exhibit 6

Elk Hills Field Geologic Data

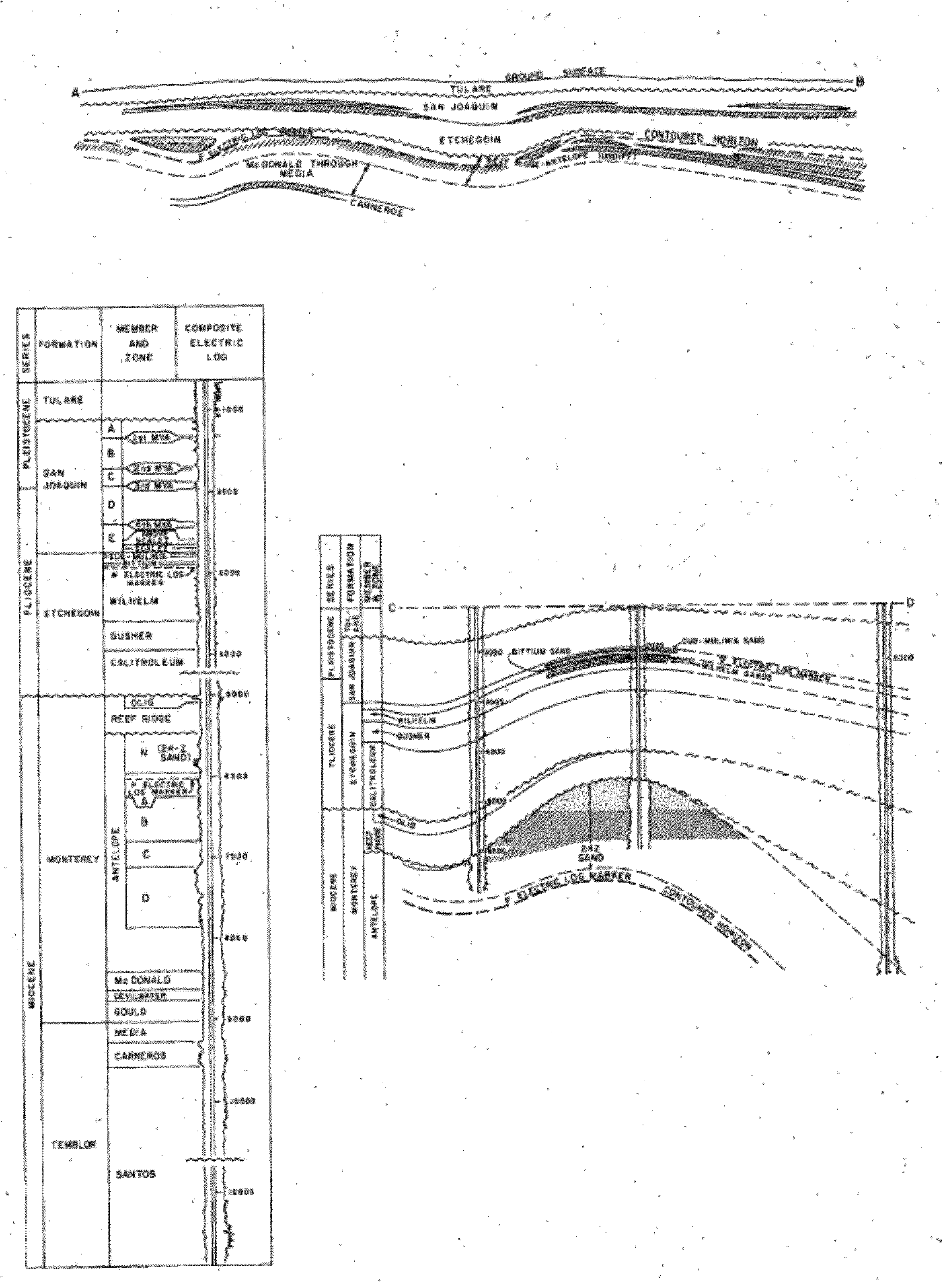
ELK HILLS OIL FIELD



CONTOURS ON P ELECTRIC LOG MARKER

Elk Hills Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

ELK HILLS OIL FIELD



Elk Hills Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

CALIFORNIA DIVISION OF OIL AND GAS

ELK HILLS OIL FIELD

Kern County

LOCATION: 10 miles north of Taft

TYPE OF TRAP: Anticlines; lithofacies changes

ELEVATION: 300 - 1,500

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Mya (gas)	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. 5X-36R	Standard Oil Co. of Calif. "Hay" 5	36 30S 23E	MD	0	33,000	May 1919
Upper [A]	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. 1-26R	Associated Oil Co. No. 1	26 30S 23E	MD	15	N.A.	Jun 1911
Olig	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. 362-30R	Same as present	30 30S 23E	MD	0	B	N.A.
Stevens	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. 5-342-31S	Standard Oil Co. of Calif. No. 42	31 30S 24E	MD	1,284	1,039	Aug 1941
Carneros	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. 555-30R	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Operator No. X-55-30R	30 30S 23E	MD	230	1,680	Jan 1952

Remarks: A Includes Scalez, Mulinia, Bittium, Wilhelm-Gusher, and Calitroleum sands.
B Not tested in this well. Potential is 1,000 Mcf per day.

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Oper. No. 555-30R	Unit Operation Naval Petroleum Reserve No. 1, Standard Oil Co. of Calif., Oper. No. X-55-30R	Aug 1950	30 30S 23E	MD	12,856	Upper Santos	early Mio

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Mya (gas)	2,300	50	Pliocene	San Joaquin	1,015	2,780	III
Scalez	2,400	80	Pliocene	San Joaquin	18	2,100	See Remarks
Mulinia	2,700	55	Pliocene	Etchegoin		1,900	See Remarks
Bittium	2,850	20	Pliocene	Etchegoin	to	2,000	See Remarks
Wilhelm-Gusher	3,000	60	Pliocene	Etchegoin		1,700	See Remarks
Calitroleum	3,200	22	Pliocene	Etchegoin	40	N.A.	See Remarks
Olig	5,000	15	late Miocene	Monterey	--	1,500	III
Stevens	6,500	800	late Miocene	Monterey	35	1,200	IV
Carneros	9,300	200	early Miocene	Temblor	50	750	IV

PRODUCTION DATA (Jan. 1, 1973) (Dry gas production data not included - see Remarks)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
776,469	13,380	7,647,760	18,590	119	281,627,730	169,552,289	17,990,462	1921	1,238	1,149	19,770

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
Water flood	1957	50,953,625	4
Gas injection for repressuring	1945	33,714,948	5

SPACING ACT: Does not apply

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Upper zones: 10 3/4" cem. 200; 7" cem. above zone; 5 1/2" liner landed through zone. Lower zones: 10 3/4" cem. 900; 7" cem. above zone; 5 1/2" liner landed through zone.

METHOD OF WASTE DISPOSAL: Percolation and evaporation sumps located on outcrop of early Tulare; injection in water flood projects.

REMARKS: BOPE not required for development wells, except in areas where shallow gas zones are present, then Class III is required. No dry gas production in 1972; cumulative dry gas production 98,499,119 Mcf; peak production (1947) 3,317,692 Mcf; 11 dry gas wells were completed.

REFERENCES: Lorshbough, A.L., Western Portion of Elk Hills Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 53, No. 1 (1967).

McLaughlin, R.P., Natural Gas Development in the Elk Hills, Kern County, Calif.: Calif. State Mining Bureau, Summary of Operations--Calif. Oil Fields, Vol. 4, May (1919).

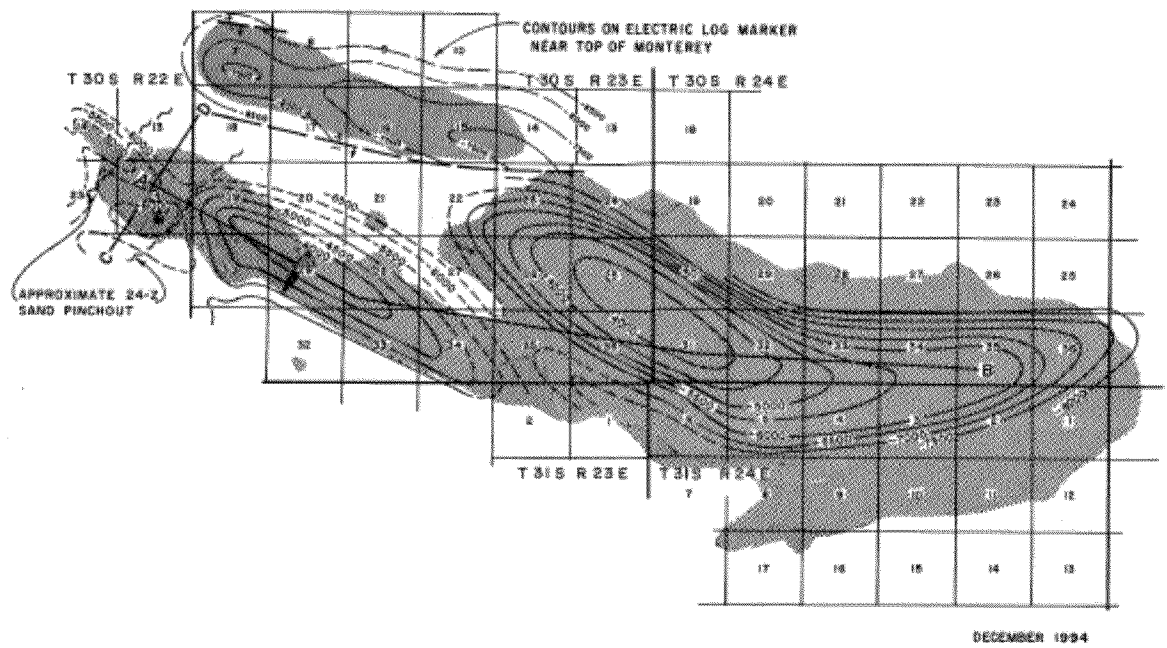
Roberts, D.C., Fossil Markers of Midway-Sunset-Elk Hills Region in Kern County, Calif.: Calif. State Mining Bureau, Summary of Operations--Calif. Oil Fields, Vol. 12, Apr (1926).

Saunders, L.W., Recent Developments in the East End of the Elk Hills Oil Field: Calif. State Mining Bureau, Summary of Operations--Calif. Oil Fields, Vol. 10, May (1925).

Thoms, C.C. and F.M. Smith, Notes on Elk Hills Oil Field: Calif. State Mining Bureau, Summary of Operations--Calif. Oil Fields, Vol. 7, No. 1 (1921).

Elk Hills Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

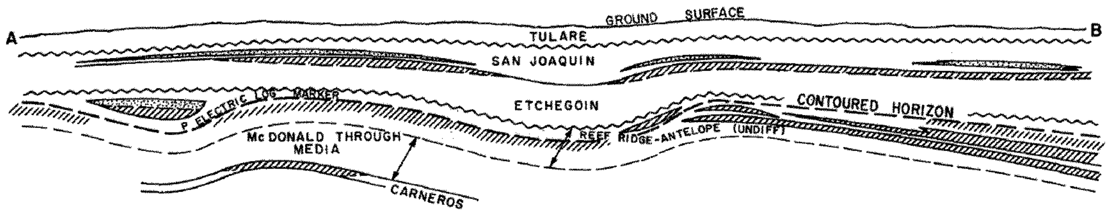
ELK HILLS OIL FIELD

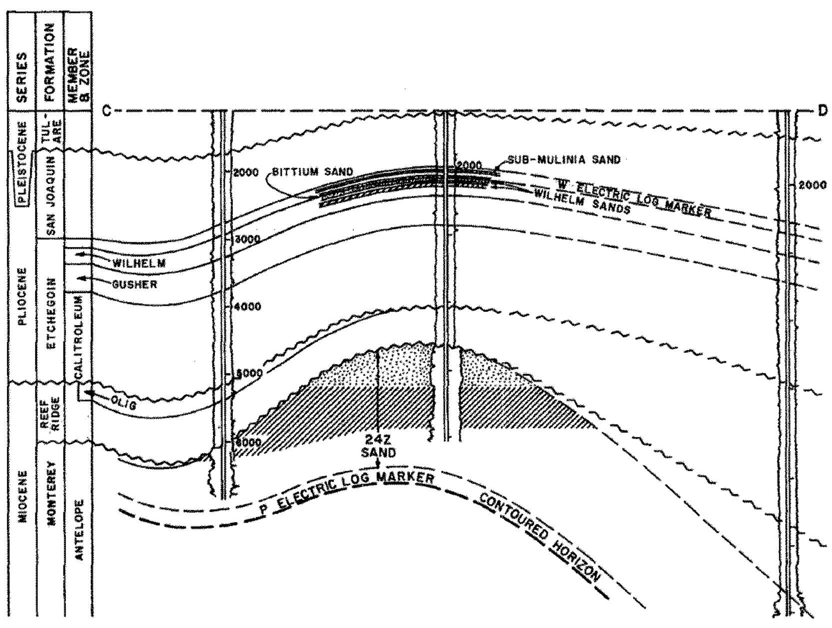


CONTOURS ON P ELECTRIC LOG MARKER

Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

ELK HILLS OIL FIELD

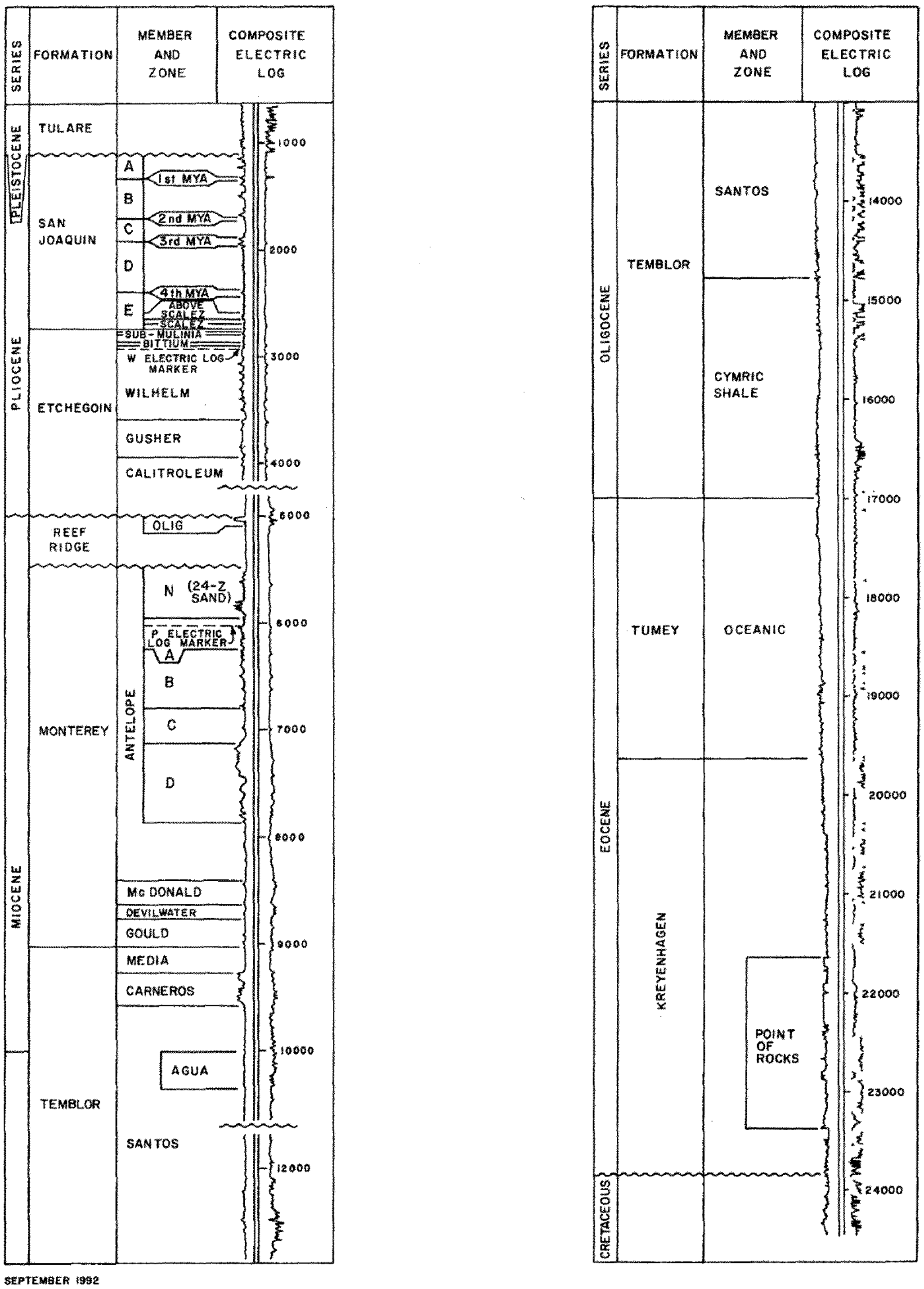




DECEMBER 1994

Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

ELK HILLS OIL FIELD



Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

COUNTY: KERN

ELK HILLS OIL FIELD

SHEET 1 OF 3

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well	Bechtel Petroleum Operations, Inc. No. 1-26R	Associated Oil Co. No. 1 a/	26 30S 23E	MD	4,030	Calitroleum (Upper)	
Deepest well	Bechtel Petroleum Operations, Inc. No. 934-29R	Same as present	29 30S 23E	MD	24,426		basement Cretaceous (?)

POOL DATA

ITEM	TULARE	MYA GAS	SCALEZ c/	MULINIA c/	BITTIUM c/	FIELD OR AREA DATA
Discovery date	March 1975	May 1919				
Initial production rates						
Oil (bbl/day)	1	-				
Gas (Mcf/day)	3	33,000				
Flow pressure (psi)						
Bean size (in.)	on pump	-				
Initial reservoir pressure (psi)	340**	1,000	1,440	1,300**	1,400**	
Reservoir temperature (°F)	91	109	110	124	130**	
Initial oil content (STB/ac.-ft.)	1,400**	-	-	-	-	
Initial gas content (MSCF/ac.-ft.)						
Formation	Tulare	San Joaquin	San Joaquin	Etchegoin	Etchegoin	
Geologic age	Pleistocene	Pliocene	Pliocene	Pliocene	Pliocene	
Average depth (ft.)	1,120	2,300	2,400	2,700	2,850	
Average net thickness (ft.)	50	50	80	55	20	
Maximum productive area (acres)	30	10,260	13,080	14,420	3,230	
RESERVOIR ROCK PROPERTIES						
Porosity (%)	30-40 (33*)	30-47 (36*)	6-43 (34*)	12-46 (34*)	33*	
S_{oi} (%)	55**	-	-	-	-	
S_{wi} (%)	45**	25	24	33	45	
S_{gi} (%)						
Permeability to air (md)	2-8,100 (2,050*)	50-11,400 (1,275*)	4-31,650 (1,428*)	3-22,340 (990*)	440*	
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	10	-	18	21	-	
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	20**	-	-	-	-	
Initial oil FVF (RB/STB)	1.02**	-	-	-	-	
Bubble point press. (psia)						
Viscosity (cp) @ °F	-	-	18 @ 132	20 @ 135	-	
Gas:						
Specific gravity (air = 1.0)	0.45**	0.65-0.70	-	-	-	
Heating value (Btu/cu. ft.)	-	1,020	-	-	-	
Water:						
Salinity, NaCl (ppm)	3,596	24,300	21,700	20,000	-	
T.D.S. (ppm)	4,560	37,300	33,400	32,400	-	
R_w (ohm/m) (77°F)	1.50	0.24	0.20	0.20	-	
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects Date started Date discontinued	cyclic steam 1975 1975	b/	waterflood c/ 1957 active steamflood c/ 1989 1991 pressure maintenance 1991 active			
Peak oil production (bbl)	6,228	7,713,136				
Year	1983	1986				
Peak gas production, net (Mcf)						
Year						

Base of fresh water (ft.): None

Remarks: Elk Hills is operated by Bechtel Petroleum Operations, Inc. (and previously by Williams Brothers Engineering Co.) for the U.S. Dept. of Energy, as Unit Operator Naval Petroleum Reserve No. 1.

a/ Standard Oil Co. of Calif. "Hay" 1, completed in January 1919, is generally regarded as the discovery well; although Associated Well No. 1 was completed earlier, in June 1911.

b/ A gas storage project was initiated in 1978.

c/ The Upper pool includes the Scalez, Mulinia, Bittium, Wilhelm, Gusher, Calitroleum, and Olig sands. All production is reported as Upper.

Selected References: Carter, R.D., R.J. Lantz, and J.C. Maher, 1975, Petroleum Geology of Naval Petroleum Reserve No. 1, Elk Hills, Kern County: USGS, Geological Survey Prof. Paper 912.
Kohlbush, R.L., 1977, Tule Elk Oil Field: Calif. Div. of Oil and Gas, Pub. No. TR19.

DATE: October 1991 *Average value **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

COUNTY: KERN

ELK HILLS OIL FIELD

SHEET 2 OF 3

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well							
Deepest well							

POOL DATA

ITEM	WILHELM c/	GUSHER c/	CALITROLEUM c/	OLIG c/	STEVENS e/	FIELD OR AREA DATA
Discovery date			June 1911	September 1950	August 1941	
Initial production rates						
Oil (bbl/day)			15	-	1,284	
Gas (Mcf/day)			-	7,500	1,039	
Flow pressure (psi)			-	JFT	75/500	
Bean size (in.)			-	1/2	32/64	
Initial reservoir pressure (psi)	1,500**	1,500**	1,600**	2,500**	3,150-3,800	
Reservoir temperature (°F)	137	137	140	165	182-206	
Initial oil content (STB/ac.-ft.)						
Initial gas content (MSCF/ac.-ft.)						
Formation	Etchegoin	Etchegoin	Etchegoin	Reef Ridge	Monterey	
Geologic age	Pliocene	Pliocene	Pliocene	Miocene	Miocene	
Average depth (ft.)	3,000	3,200	3,200	5,000	5,900-7,100	
Average net thickness (ft.)	60	60	22	15	150-400	
Maximum productive area (acres)	5,040	2,760	2,080	-	-	
RESERVOIR ROCK PROPERTIES						
Porosity (%)	17-44 (32*)	20-47 (33*)	25-38 (32*)	8-30 (21*)	4-35 (21*)	
Soi (%)						
Swi (%)	51	58	43	45	13-36 f/	
Sgi (%)						
Permeability to air (md)	1-3,050 (82*)	3-4,920 (190*)	1-140 (17*)	1-230 (40*)	1-4,750 (150*)	
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	40	-	40	-	34-38	
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)						
Initial oil FVF (RB/STB)						
Bubble point press. (psia)						
Viscosity (cp) @ °F	1.5 @ 131	-	-	-	1.7 @ 207 g/	
Gas:						
Specific gravity (air = 1.0)						
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	20,500	16,500	-	16,300	11,000-16,000	
T.D.S. (ppm)	32,300	26,000	-	32,900	22,000-29,000	
R_w (ohm/m) (77°F)	0.20	-	-	0.22	0.25-0.31	
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects / Date started / Date discontinued					waterflood (24Z) 1965 active waterflood h/ 1978 active pressure maintenance 1976 active waterflood g/ 1989 active waterflood (2B)g/ 1995 active	
Peak oil production (bbl)				17,538,730 d/	42,345,326	
Year				1978	1981	
Peak gas production, net (Mcf)				6,943,057 d/	58,774,341	
Year				1981	1985	

Base of fresh water (ft.):

Remarks:
d/ Upper pool production.
e/ The Stevens pool includes the following zones: N,A,B,C,D,DD, and E, and the following pools: Main Body Stevens, Western 31S, 26R, 2B, 29R, and 24Z.
f/ Several intervals are shale.
g/ B zone.
h/ (Main Body B)

Selected References: Lorshbough, A.L., 1967, Western Portion of Elk Hills Oil Field: Calif. Div. of Oil & Gas, Summary of Operations -- Calif. Oil Fields, Vol. 53, No. 1.
McLaughlin, R.P., 1919, Natural Gas Development in the Elk Hills, Kern County: Calif. State Mining Bureau, Summary of Operations -- Calif. Oil Fields, Vol. 4.

DATE: November 1997 *Average value **Estimated value

DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

COUNTY: KERN

ELK HILLS OIL FIELD

SHEET 3 OF 3

DISCOVERY WELL AND DEEPEST WELL

	Present operator and well designation	Original operator and well designation	Sec. T. & R.	B.&M.	Total depth (feet)	Pool (zone)	Strata & age at total depth
Discovery well							
Deepest well							

POOL DATA

ITEM	NORTHWEST STEVENS 1/	CARNEROS	AGUA			FIELD OR AREA DATA
Discovery date	September 1973	January 1962	April 1977			
Initial production rates						
Oil (bbl/day)	2,300	230	203			
Gas (Mcf/day)	1,100	1,716	1,865			
Flow pressure (psi)	1,200/1,100	160/pkr	2,055/2,400			
Bean size (in.)	16/64	64/64	8/64			
Initial reservoir pressure (psi)	4,175	7,500**	6,935			
Reservoir temperature (°F)	250	252	224			
Initial oil content (STB/ac.-ft.)						
Initial gas content (MSCF/ac.-ft.)						
Formation	Monterey	Temblor	Temblor			
Geologic age	Miocene	Miocene	Oligocene			
Average depth (ft.)	8,900	9,300	9,600			
Average net thickness (ft.)	200	170	480			
Maximum productive area (acres)	-	1,000	40			21,170
RESERVOIR ROCK PROPERTIES						
Porosity (%)	19	11-18 (15*)	-			
Soi (%)						
Swi (%)	25-30	25-30	25**			
Sgi (%)						
Permeability to air (md)	100-300	1-25 (6*)	-			
RESERVOIR FLUID PROPERTIES						
Oil:						
Oil gravity (°API)	15-38 (25*)	50	37			
Sulfur content (% by wt.)						
Initial solution GOR (SCF/STB)	535	7,600	9,000			
Initial oil FVF (RB/STB)	1.33	-	-			
Bubble point press. (psia)	3,200	-	-			
Viscosity (cp) @ °F						
Gas:						
Specific gravity (air = 1.0)	0.68-0.76	-	-			
Heating value (Btu/cu. ft.)						
Water:						
Salinity, NaCl (ppm)	-	12,000	-			
T.D.S. (ppm)	15,000-28,000	21,000	-			
R_w (ohm/m) (77°F)	0.30-0.50	0.37	-			
ENHANCED RECOVERY PROJECTS						
Enhanced recovery projects	waterflood					
Date started	1982					
Date discontinued	active					
	pressure maintenance					
	1992					
	active					
Peak oil production (bbl)	7,931,570	208,357	29,608			63,169,629
Year	1982	1983	1983			1981
Peak gas production, net (Mcf)	12,902,685	7,058,372	58,025			67,125,403
Year	1983	1983	1983			1986

Base of fresh water (ft.):

Remarks: 1/ Formerly Tule Elk oil field.
2/ (sub-scalez)
3/ (Western 31S sand)

Selected References:

DATE: October 1991 *Average value **Estimated value

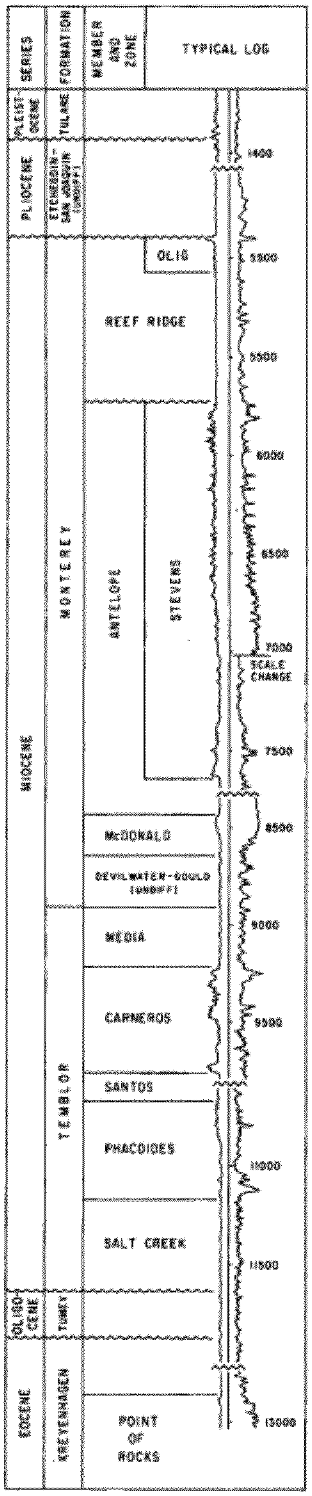
DEPARTMENT OF CONSERVATION / DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES

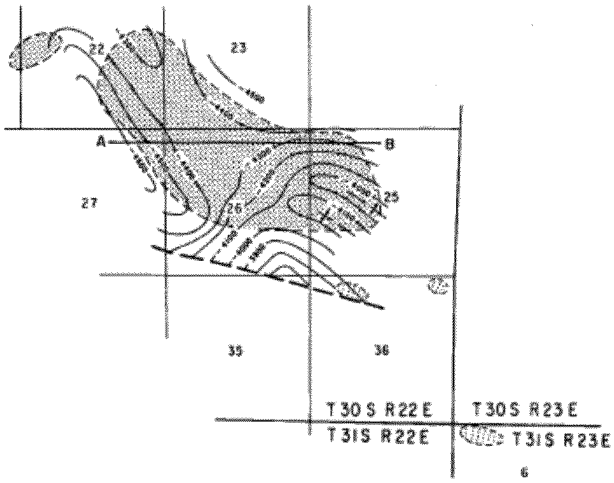
Elk Hills Field Geologic Data: 1998 *California Oil and Gas Fields* (Post-Primacy Agreement)

Exhibit 7

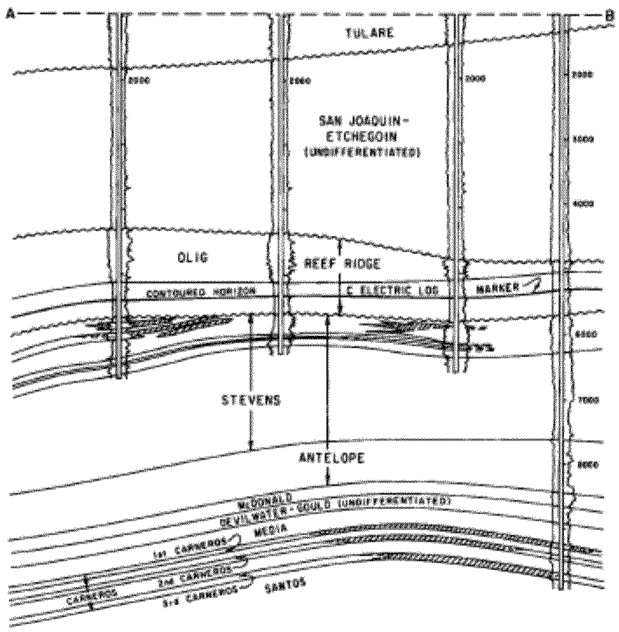
Asphalto Field Geologic Data

ASPHALTO OIL FIELD





CONTOURS ON C ELECTRIC LOG MARKER



Asphalto Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

CALIFORNIA DIVISION OF OIL AND GAS

ASPHALTO OIL FIELD

Kern County

LOCATION: 12 miles northwest of Taft

TYPE OF TRAP: Anticline; lensing; angular unconformity

ELEVATION: 550

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Etchegoin	Crown Central Petroleum Corp. "Mason" 2	Western Oil Fields Corp. No. 2	6 31S 23E	MD	153	N.A.	Jul 1923
Olig	W.T. Woodward and American Placers Inc. "Flickenger" 1	MacDonald, Burns and Norris "Flickenger" 1	36 30S 22E	MD	50	5,795	Oct 1944
Stevens	General Crude Oil Co., Opr. "Standard Oil Co." 18	E.A. Bender, Opr. "Standard Oil Co." 18	25 30S 22E	MD	312	825	Dec 1962
Antelope Shale	Bob Ferguson Independent No. 32X-36	Same as present	36 30S 22E	MD	110	43	Jan 1967
Carneros	Standard Oil Co. of Calif. No. 545	Same as present	25 30S 22E	MD	446	1,756	Nov 1967

Remarks:

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
Standard Oil Co. of Calif. No. 532	Same	May 1968	25 30S 22E	MD	13,455	Point of Rocks	late Eo

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Etchegoin	3,050	15	Pliocene	Etchegoin	19	N.A.	II
Olig	4,825	20	late Miocene	Monterey	30 - 75	N.A.	III
Stevens	5,660	165	late Miocene	Monterey	36	1,270	III
Antelope Shale	7,550	200	late Miocene	Monterey	36	N.A.	III
Carneros	8,510	200	early Miocene	Temblor	35	N.A.	IV

PRODUCTION DATA (Jan. 1, 1973)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
929,642	5,729,498	4,955,511	830	58	28,851,621	51,799,060	5,202,894	1964	110	85	890

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
--			

SPACING ACT: Applies except for NW 1/4 of Sec. 6, T. 31S., R. 23E.

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Miocene zones: 10 3/4" cem 500; 7" or 5" cemented through zone.

METHOD OF WASTE DISPOSAL: Unlined sumps.

REMARKS: Asphalto Oil Field derives its name from mining activities predating the turn of the century. Asphalt and viscous oil was recovered from surface outcrops, pits and shallow wells.

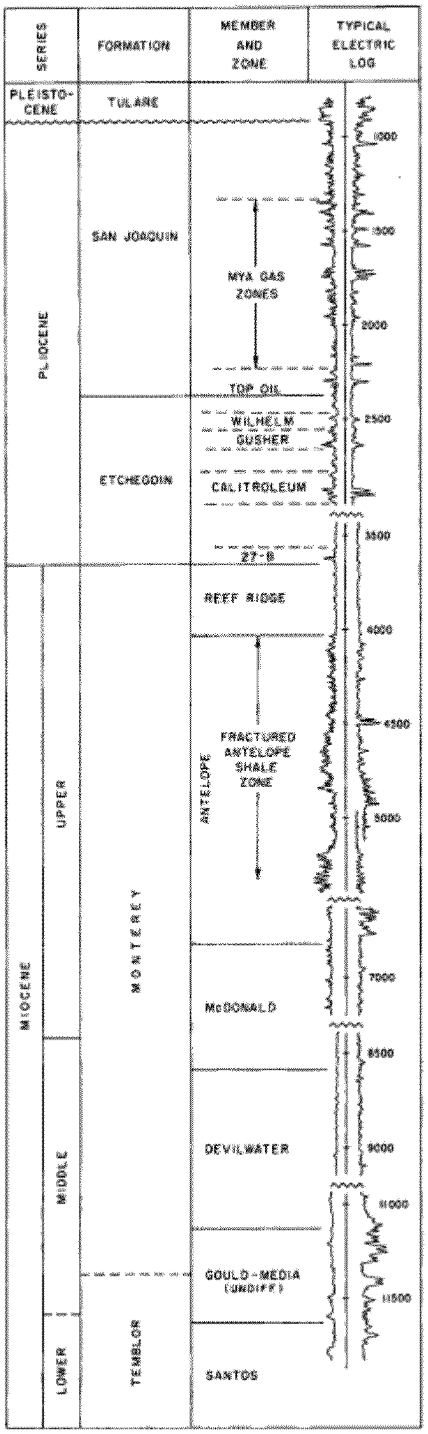
REFERENCES: Anderson, D.N., Stevens Pool of Asphalto Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 49, No. 1 (1963).

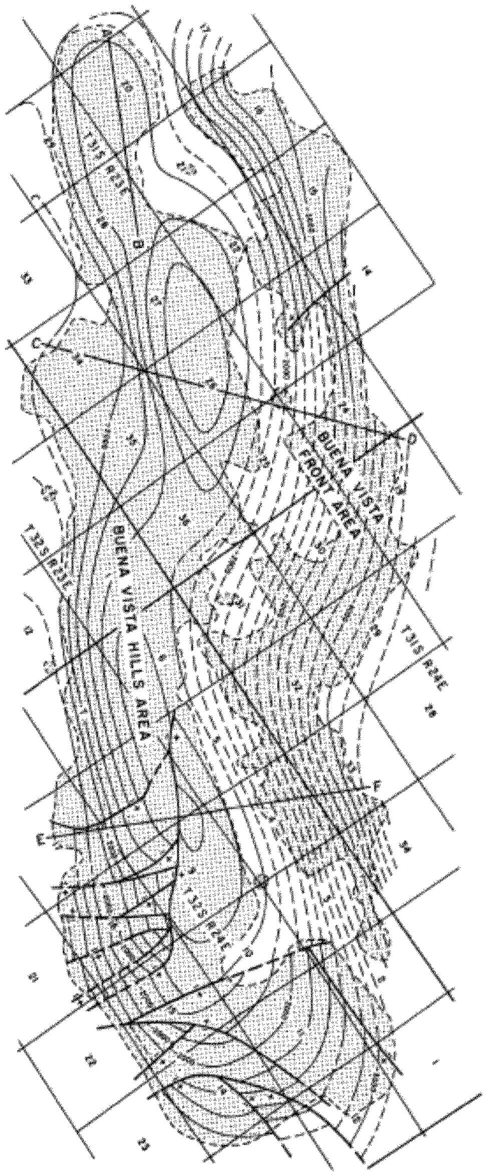
Asphalto Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

Exhibit 8

Buena Vista Field Geologic Data

BUENA VISTA OIL FIELD





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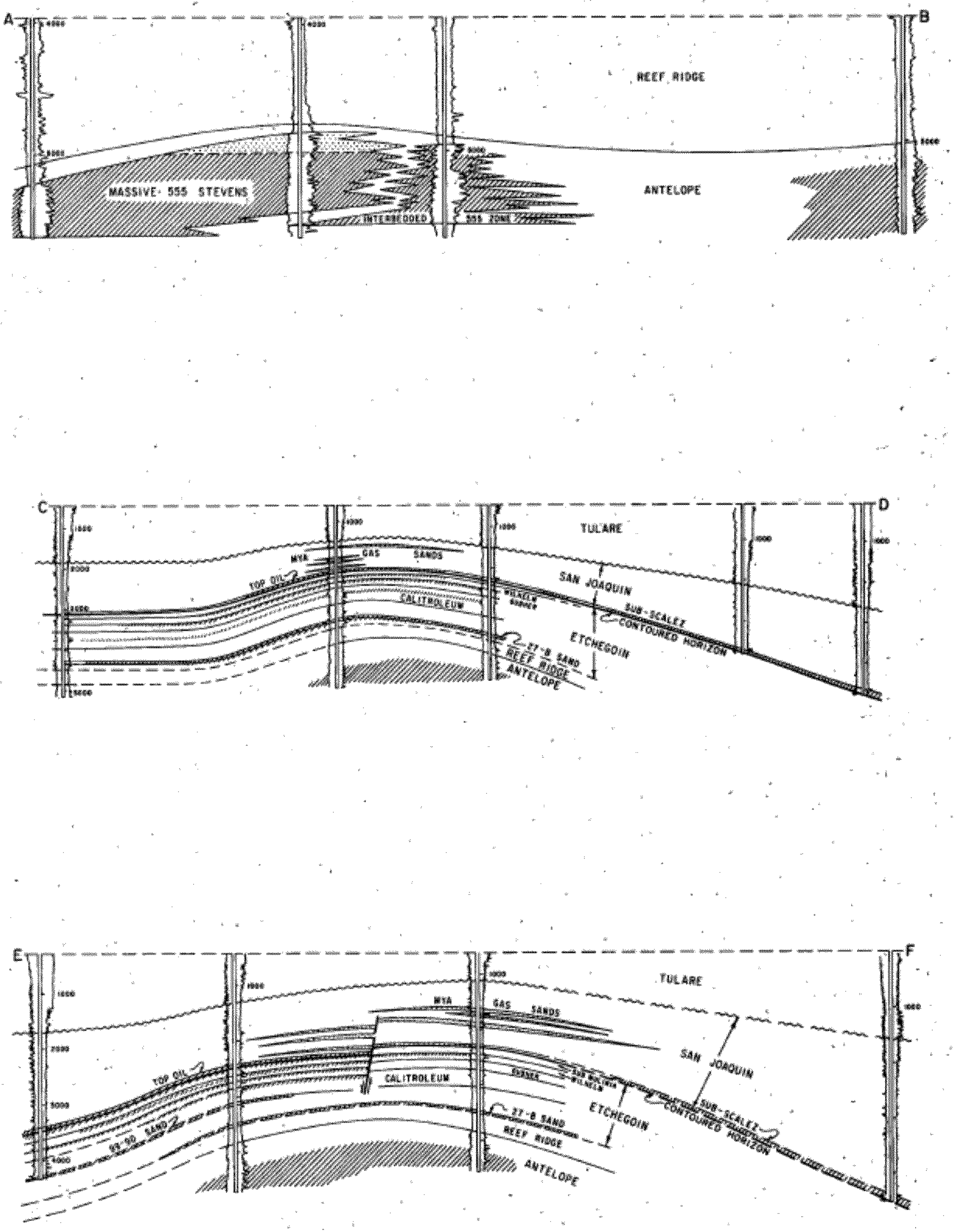
Buena Vista Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

BUENA VISTA OIL FIELD

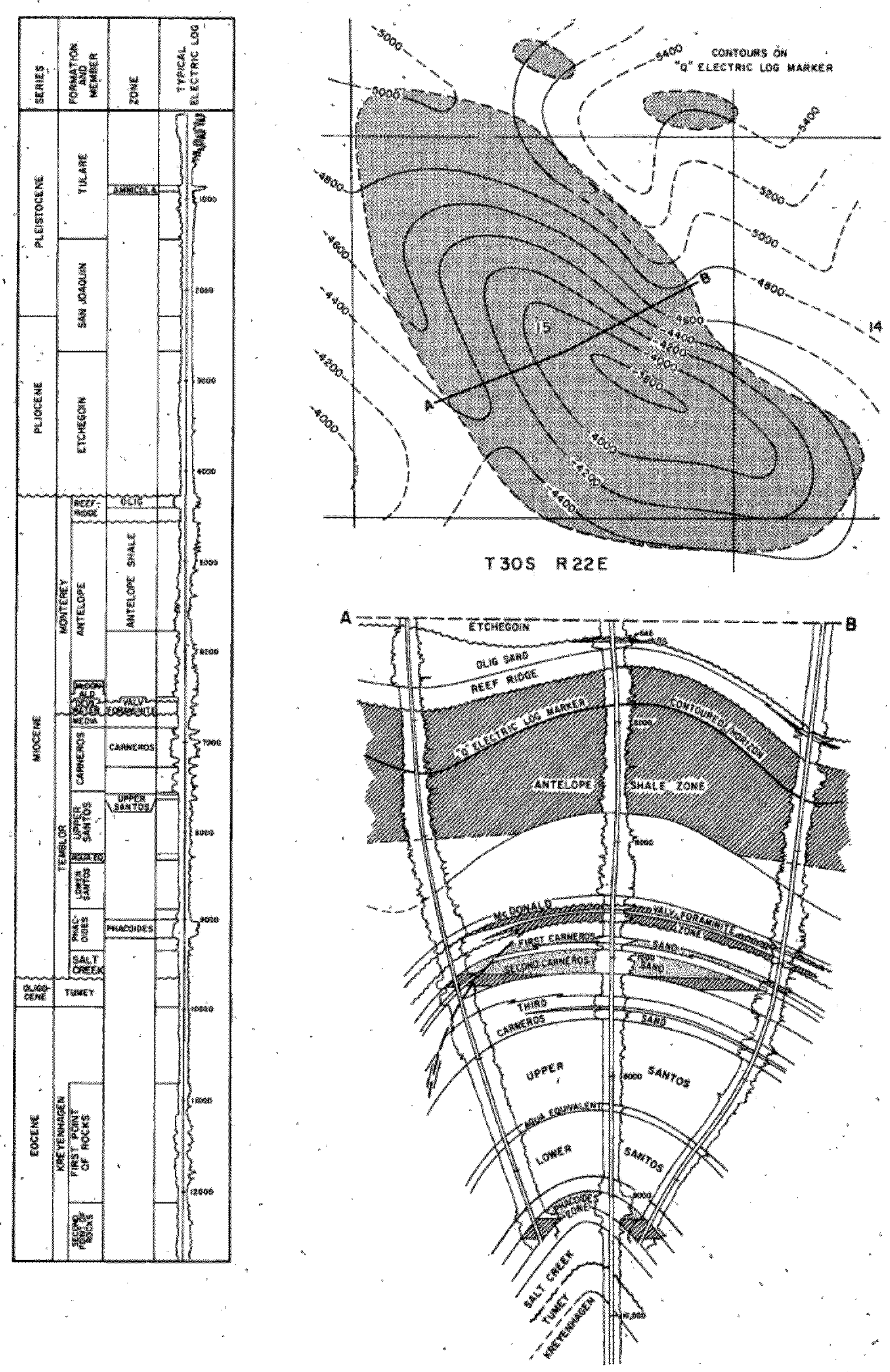


Buena Vista Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

Exhibit 9

Railroad Gap Field Geologic Data

RAILROAD GAP OIL FIELD



Railroad Gap Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

CALIFORNIA DIVISION OF OIL AND GAS

RAILROAD GAP OIL FIELD
Kern County

LOCATION: 15 miles northwest of Taft

TYPE OF TRAP: Anticline; fractured shale

ELEVATION: 925

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production: Oil (bbl)	Initial daily production: Gas (Mcf)	Date of completion
Amnicola	Standard Oil Co. of Calif. No. 1-2	Same as present	15 30S 22E	MD	26	N.A.	May 1965
2nd Mya (Gas)	Standard Oil Co. of Calif. No. 5-6	Same as present	15 30S 22E	MD	0	300	Aug 1960
Olig	Standard Oil Co. of Calif. No. 366	Standard Oil Co. of Calif. No. 66	15 30S 22E	MD	45	1,441	Jun 1964
Antelope Shale	Signal Oil and Gas Co. "Signal-Pike" 1	Same as present	10 30S 22E	MD	45	N.A.	Sep 1948
Valv	Standard Oil Co. of Calif. No. 477	Standard Oil Co. of Calif. No. 77	15 30S 22E	MD	82	254	Apr 1964
Carneros	Standard Oil Co. of Calif. No. 568	Same as present	15 30S 22E	MD	329	183	May 1964
Phacoides	Standard Oil Co. of Calif. No. 555	Same as present	15 30S 22E	MD	170	1,700	Jul 1964

Remarks:

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth: Strata	At total depth: Age
Standard Oil Co. of Calif. No. 555	Standard Oil Co. of Calif. No. 55	Feb 1964	15 30S 22E	MD	12,731	Point of Rocks	Eocene

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic: Age	Geologic: Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Amnicola	1,100	60	Pleistocene	Tulare	14	225	None
2nd Mya (Gas)	2,300	25	Pleistocene	San Joaquin	1,220	N.A.	None
Olig	4,400	50	late Miocene	Monterey	29	955	II
Antelope Shale	5,000	1,100	late Miocene	Monterey	33	N.A.	III
Valv	6,700	120	m Miocene	Monterey	34	1,830	III
Carneros	7,000	250	early Miocene	Temblor	34	1,530	IV
Upper Santos	8,000	50	early Miocene	Temblor	30	N.A.	IV
Phacoides	9,100	180	early Miocene	Temblor	34	325	IV

PRODUCTION DATA (Jan. 1, 1973) (Dry gas production data not included - see Remarks)

1972 Production: Oil (bbl)	1972 Production: Net gas (Mcf)	1972 Production: Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production: Oil (bbl)	Cumulative production: Gas (Mcf)	Peak oil production: Barrels	Peak oil production: Year	Total number of wells: Drilled	Total number of wells: Completed	Maximum proved acreage
303,693	5,450,269	1,436,883	480	40	7,591,530	57,494,928	1,472,297	1965	81	71	490

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
Cyclic-steam	1965	347,132	10

SPACING ACT: Applies

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Pleistocene: 7" cem. above zone; 5 1/2" liner landed through zone. Middle and late Miocene: 10 3/4" cem. 1,200; 7" cem. above zone; 5 1/2" liner landed through zone. Lower Miocene: 11 3/4" cem. 1,500; 7: cem. through zone.

METHOD OF WASTE DISPOSAL: Unlined sumps are permitted.

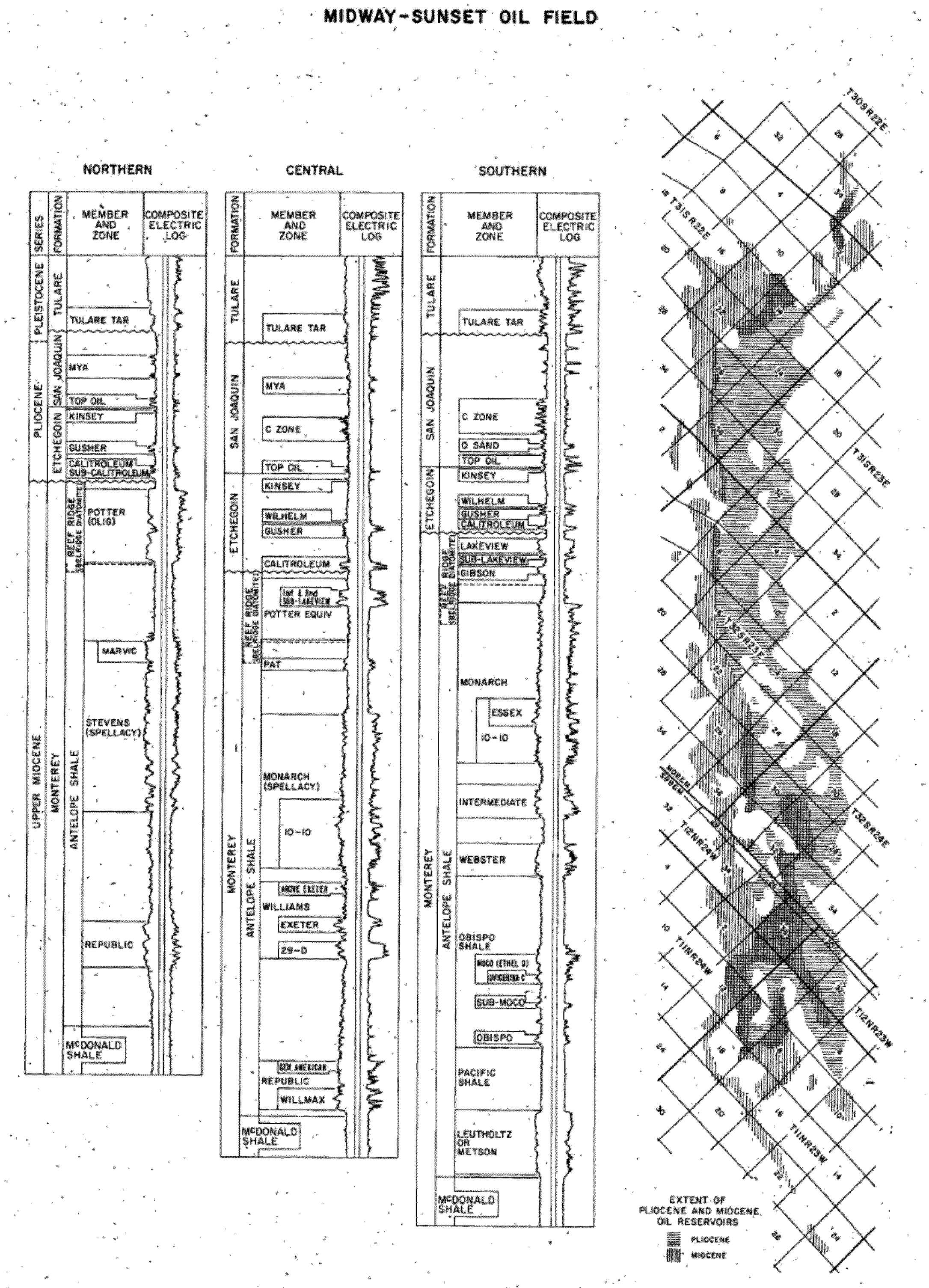
REMARKS: No dry gas production in 1972; cumulative dry gas production 676,765 Mcf; 2 dry gas wells were completed. The Valv zone is also referred to as Foraminite.

REFERENCES: Hardoin, J.L., Railroad Gap Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 51, No. 1 (1965).

Railroad Gap Field Geologic Data: 1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

Exhibit 10

Midway-Sunset Field Geologic Data

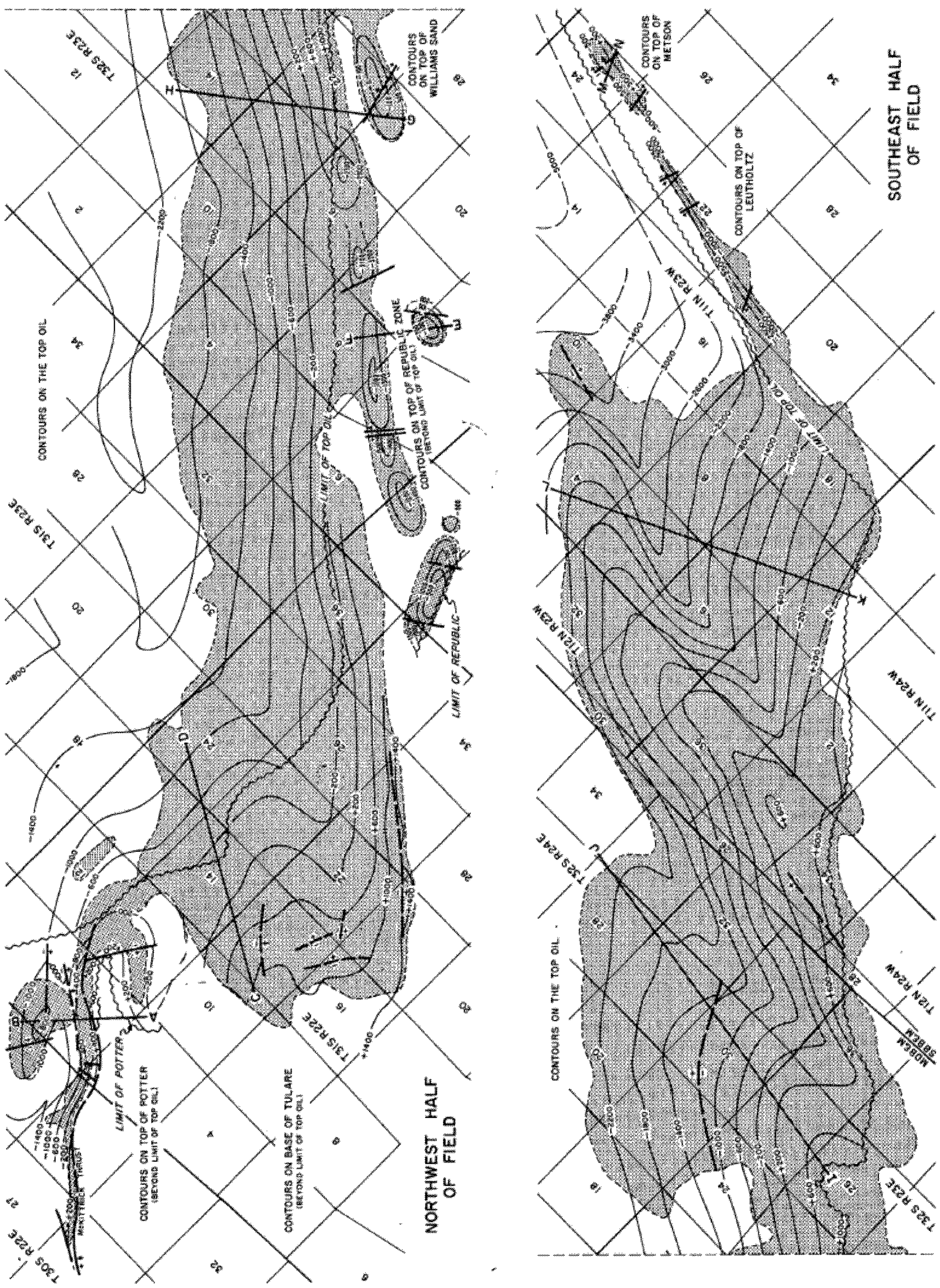


Midway-Sunset Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

The extent of the aquifer exemption in the Pleistocene Tulare Formation is not shown on this map.

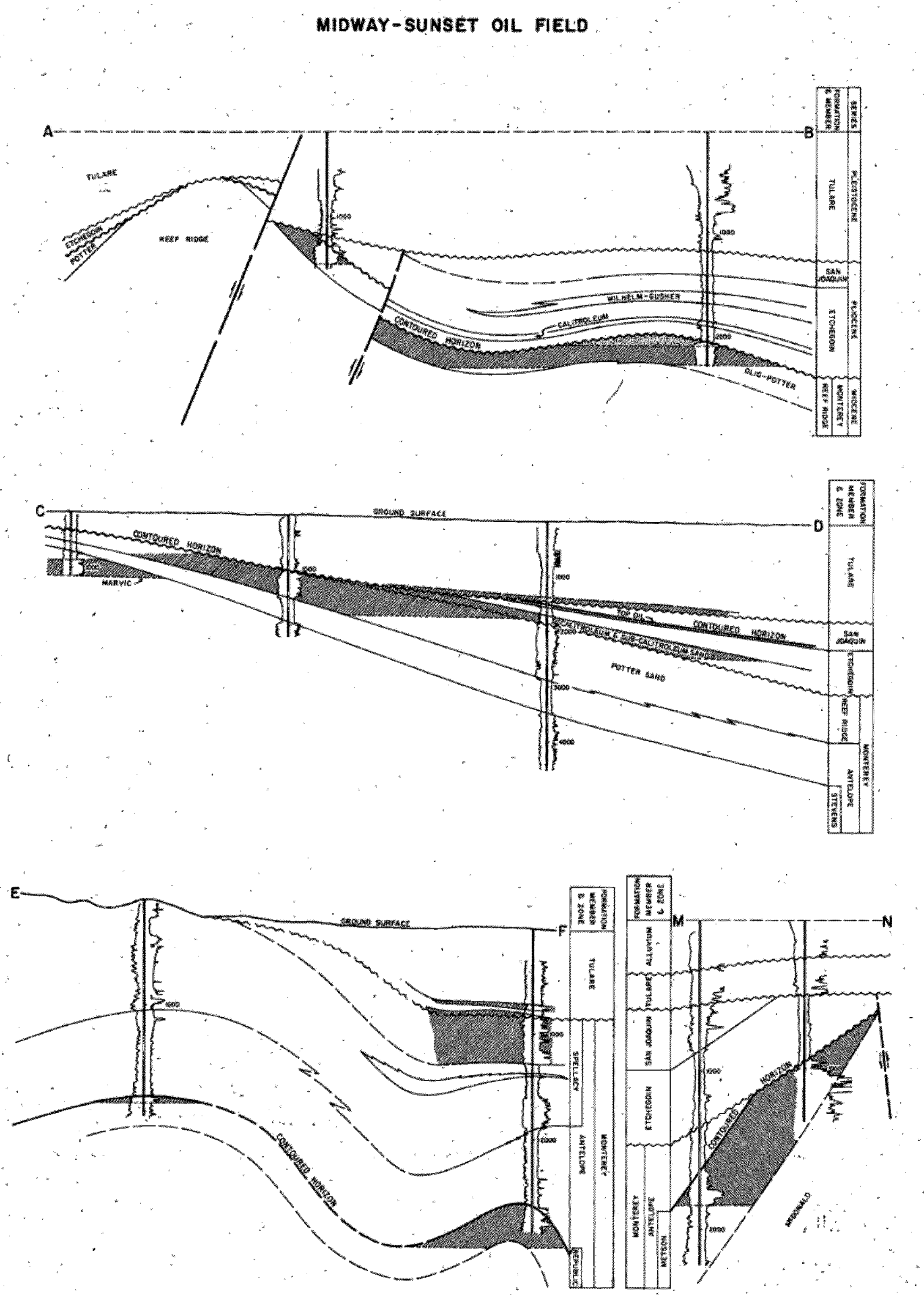
MIDWAY-SUNSET OIL FIELD



Midway-Sunset Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

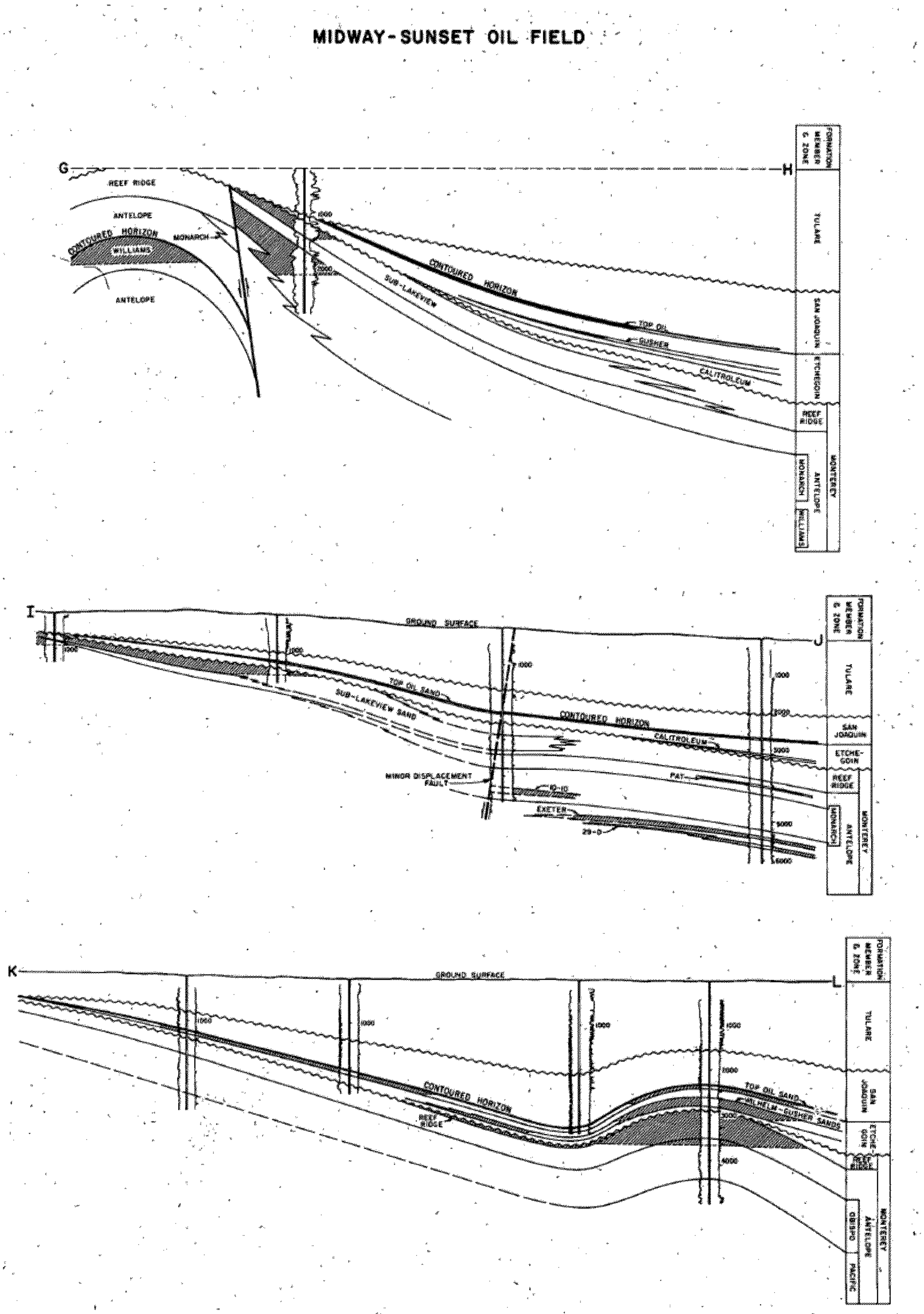
The extent of the Tulare aquifer exemption is shown by portions of the shaded areas on this map.



Midway-Sunset Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

The extent of the Tulare aquifer exemption is shown by shaded areas in that zone.



Midway-Sunset Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

The extent of the Tulare exempt aquifer is shown by shaded areas in that zone.

CALIFORNIA DIVISION OF OIL AND GAS

MIDWAY-SUNSET OIL FIELD

LOCATION: Vicinity of Taft, about 28 miles southwest of Bakersfield

Kern and San Luis Obispo Counties

TYPE OF TRAP: Regional homocline modified by: anticlines; anticlinal noses; lithofacies variations; angular unconformities; lenticular sands; fractured shales

ELEVATION: 600 - 1,750

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Tulare	Operator name and well number unknown	Same as present	N.A.	MD	N.A.	N.A.	prior to 1894
Mya Tar	Getty Oil Co. No. 101	Associated Oil Co. No. 101	2 31S 22E	MD	10	N.A.	Jan 1920
Top Oil	Operator name and well number unknown	Operator name and well number unknown	N.A.	MD	N.A.	N.A.	N.A.
Kinsey	Same as above	Same as above	N.A.	MD	N.A.	N.A.	N.A.
Wilhelm	Same as above	Same as above	N.A.	MD	N.A.	N.A.	N.A.
Gusher	Chanslor-Western Oil & Dev. Co. No. 2	Chanslor-Canfield Midway Oil Co. No. 2 A	6 32S 23E	MD	3,000	N.A.	Nov 1909
Calitroleum	Operator name and well number unknown	Same as present	N.A.	MD	N.A.	N.A.	N.A.
Lakeview and Sub-Lakeview	Mobil Oil Corp. "Lakeview" 1	Lake View Oil Co. B No. 1	25 12N 24W	SB	68,000	N.A.	Mar 1910
Potter	Exeter Oil Co. Ltd. "Exeter-BAOC" 101-15	Dominion Oil Co. No. 1	15 31S 22E	MD	100	N.A.	Jan 1910
Marvic	Mobil Oil Corp. "Marvic" 1	Marvic Associates Ltd. No. 1	16 31S 22E	MD	72	N.A.	May 1941
Monarch	Standard Oil Co. of Calif. "Monarch" 28	Sunset-Monarch Oil Co. No. 1	2 11N 24W	SB	N.A.	N.A.	about 1902
Webster	Directors Oil Co. No. 7	Ruby Oil Co. No. 7	2 11N 24W	SB	35	N.A.	Dec 1913
Moco	Mobil Oil Corp. "Moco 35" WT 504	General Petroleum Corp. "Moco 35" 204	35 12N 24W	SB	188	20	Jul 1957
Obispo	Union Oil Co. of Calif. "Obispo" 6	Obispo Oil Co. No. 6	32 12N 23W	SB	6,000	N.A.	Sep 1925
Pacific	Mobil Oil Corp. "Pacific" 4	General Petroleum Corp. "Pacific" 4	32 12N 23W	SB	1,078	N.A.	Jun 1947
Metson	Tenneco Oil Co. "Metson" 47-24	Bankline Oil Co. "Metson" 47-24	24 11N 23W	SB	27	0	Mar 1953
Leutholtz	Gulf Oil Corp. No. 2 - "I.M. Woodward USL"	Western Gulf Oil Co. No. 2 - "I.M. Woodward USL"	21 11N 23W	SB	1,021	120	Aug 1945
Republic	Shell Oil Co. "Sec. 8" 25	Republic Petroleum Co. No. 25	8 32S 23E	MD	1,114	350	Mar 1928

Remarks: A First of over 100 gushers in field and is the first significant production from the Gusher zone.
B "America's Most Spectacular Gusher" blew out and flowed uncontrolled for 18 months after which the flow stopped probably because the bottom of the hole caved in. It was estimated that the early flow rate was about 68,000 b/d and that production amounted to 8-1/4 million barrels oil of which 3-1/2 million barrels was lost by evaporation and seepage.

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
The Superior Oil Co. "C.W.O.D." 58-21	Same	Nov 1957	21 32S 23E	MD	14,504	lower Santos	early Mio

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Tulare	200 - 1,400	50 - 200	Pleistocene	Tulare	13	200 - 1,000	None
Mya Tar	1,100	150	Pliocene	San Joaquin	12	260	None
Top Oil	500 - 2,500	20 - 50	Pliocene	San Joaquin	15 - 23	1,490 - 2,160	None
Kinsey	2,000 - 3,600	15 - 175	Pliocene	Etchegoin	14 - 26	1,500 - 1,860	None
Wilhelm	2,000 - 3,000	100	Pliocene	Etchegoin	14 - 26	1,700 - 2,100	None
Gusher	2,000 - 3,000	75	Pliocene	Etchegoin	14 - 26	1,440 - 1,580	None
Calitroleum	1,500 - 4,500	80	Pliocene	Etchegoin	14 - 26	1,620 - 2,040	None
Lakeview	2,600 - 3,300	20 - 200	late Miocene	Monterey	21	1,670	None
Sub-Lakeview	400 - 3,100	10 - 300	late Miocene	Monterey	22	440	III
Potter	200 - 2,500	60 - 500	late Miocene	Monterey	14	5 - 400	None
Marvic	1,000	200	late Miocene	Monterey	13	40	None
Monarch	600 - 2,000	50 - 400	late Miocene	Monterey	13 - 17	50 - 1,300	None
Webster	1,500 - 1,800	50 - 250	late Miocene	Monterey	14	N.A.	None
Moco	2,150	70 - 450	late Miocene	Monterey	15	980	III
Obispo	3,600	50 - 1,500	late Miocene	Monterey	14 - 27	970	III
Pacific	3,700	50 - 300	late Miocene	Monterey	16	600	III
Metson	1,250	400	late Miocene	Monterey	8 - 12	790	None
Leutholtz	3,200	40 - 400	late Miocene	Monterey	15 - 24	550	III
Republic	1,300 - 4,900	150	late Miocene	Monterey	12 - 24	70	III

PRODUCTION DATA (Jan. 1, 1973)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
34,579,424	5,810,674	66,810,031	24,370	5,549	1,157,831,025	500,583,802	34,579,424	1972	10,318	9,486	28,090

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
Water flood	1954	20,838,718	15
Steam flood	1963	15,398,177	47
Cyclic-steam	1963	195,087,515	4,870
Air injection for a fire flood	1960	N.A.	24
Gas injection for pressure maintenance	1944	43,302,959	7

SPACING ACT: Does not apply except at extreme southeast end of field.

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Various; depending on zone and location.

METHOD OF WASTE DISPOSAL: Percolation and evaporation sumps; during 1972, 6,222,115 bbl. of waste water was injected into 7 disposal wells.

REMARKS: In a report by W.L. Watts titled "Sunset Oil Claims" in the Calif. State Mining Bureau Bull. No. 3 (1894) mention is made of steam injection into a well in Sec. 21, T. 11N., R. 23W., S.B.B. & M to reduce the viscosity of the heavy oil so it can be pumped to the surface. Later application and refinement of this method of reservoir stimulation was a significant contributing factor toward attaining the peak oil production in 1972.

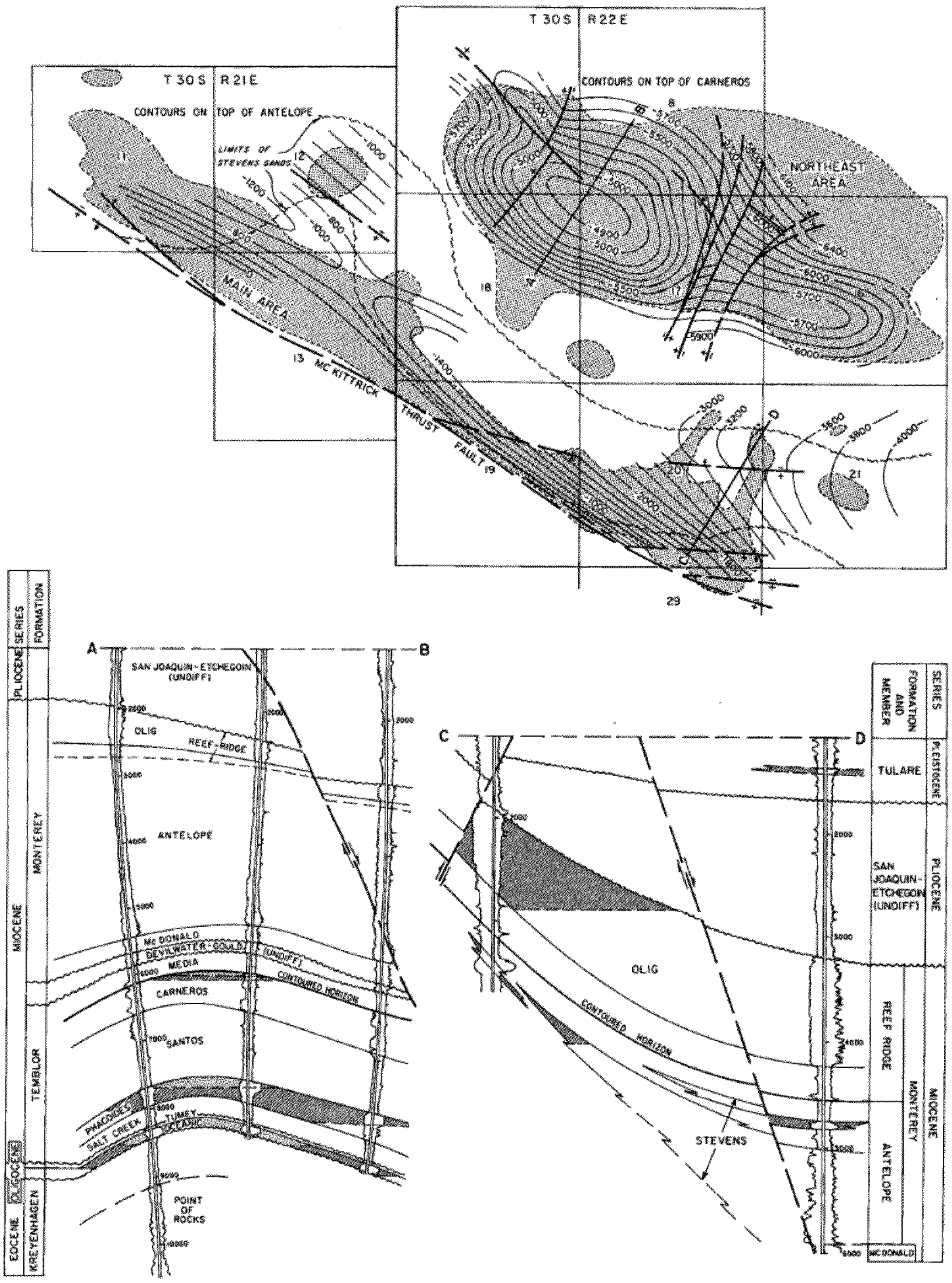
Midway-Sunset Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

Exhibit 11

McKittrick Field Geologic Data

MC KITTRICK OIL FIELD



McKittrick Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

The extent of the exempt aquifer in the Tulare Formation is shown the shaded area on the cross-sections.

CALIFORNIA DIVISION OF OIL AND GAS

MCKITTRICK OIL FIELD
Kern County

LOCATION: 14 miles northwest of Taft

TYPE OF TRAP: See Areas

ELEVATION: 850 - 1,500

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Tulare	Operator name and well number unknown	Same as present	N.A.	MD	N.A.	N.A.	N.A.

Remarks:

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
Standard Oil Co. of Calif., Opr. "Jacobson" 572R	Standard Oil Co. of Calif. "Jacobson" 572	Jan 1965	18 30S 22E	MD	10,864	Point of Rocks	late Eo

PRODUCING ZONES (See areas)

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required

PRODUCTION DATA (Jan. 1, 1973) (Dry gas production data not included - see Northeast Area)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
8,642,029	10,652,584	16,007,113	3,290	927	192,393,692	148,134,024	11,425,935	1966	1,597	1,420	3,370

STIMULATION DATA (Jan. 1, 1973) (See areas)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection

SPACING ACT: See areas.

BASE OF FRESH WATER: See areas.

CURRENT CASING PROGRAM: See areas.

METHOD OF WASTE DISPOSAL: See areas.

REMARKS: In the early 1860's pits and test holes were dug into bituminous outcrops from which asphaltum was bailed. Beginning in 1887 several shallow low volume oil wells were drilled. Circa 1896 Klondike Oil Co. brought in the "Shamrock" well, a 1,300 barrels-of-oil-per-day gusher.

REFERENCES: See areas.

McKittrick Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

CALIFORNIA DIVISION OF OIL AND GAS

MAIN AREA

MCKITTRICK OIL FIELD

Kern County

LOCATION: See map sheet of McKittrick Oil Field

TYPE OF TRAP: Faulted homocline

ELEVATION: 1,150 - 1,500

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Tulare	Operator name and well number unknown	Same as present	N.A.	MD	N.A.	N.A.	N.A.
Olig	Getty Oil Co. "Shamrock" 1	Klondike Oil Co. "Shamrock" 1	19 30S 22E	MD	1,300	N.A.	about 1896
Basal Reef Ridge	Estate of Frank Rice Short "Tulare" 2	Harry H. Magee, Opr. "Tulare" 2	20 30S 22E	MD	4	0	Feb 1944
Stevens	Rothschild Oil Co. "SP" 3	Same as present	21 30S 22E	MD	280	N.A.	Jan 1964

Remarks:

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
Occidental Petroleum Corp. "Standard-Gabriel" 556X-12Y	J. Ainslie Bell, Opr. "Standard-Gabriel" 556X-12Y	Feb 1966	12 30S 21E	MD	9,492	Media	early Mio

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Tulare	500	300	Pleistocene	Tulare	12 - 19	50	None
Olig	800	300	late Miocene	Monterey	12 - 16	450	None
Basal Reef Ridge	1,500	400	late Miocene	Monterey	14 - 21	530	None
Stevens	2,000 - 4,750	175	late Miocene	Monterey	18 - 32	1,200	III

PRODUCTION DATA (Jan. 1, 1973)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
5,436,614	634,289	11,725,032	1,370	650	149,730,817	28,592,313	5,807,360	1909	1,206	1,074	1,440

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
Cyclic-steam	1962	34,806,835	716

SPACING ACT: Does not apply

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Stevens zone wells: 10 3/4" cem. 500; 7" cem. above zone; 5 1/2" liner landed through zone. Other zones: 8 5/8" or 7" cem. above zone; 6 5/8" or 5 1/2" liner landed through zone.

METHOD OF WASTE DISPOSAL: Evaporation and percolation sumps; injection wells.

REMARKS: Lost circulation often experienced while drilling through depleted portions of Olig zone. A steam flood project started in 1965 was discontinued in 1968 after the injection of 1,246,184 bbls. of water (in the form of steam). A great number of vertebrate fossils of Pleistocene age have been recovered by a research group from University of Calif. in excavations of brea outcrops in Sec. 29, T. 30S., R. 22E.

REFERENCES: Hardoin, J.L., Stevens Pool of the Main Area of McKittrick Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 52, No. 1 (1966).
Zulberti, J.L., McKittrick Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 42, No. 1 (1956).

McKittrick Field Geologic Data, Main Area:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

LOCATION: See map sheet of McKittrick Oil Field

TYPE OF TRAP: Faulted anticline

ELEVATION: 850 - 1,125

DISCOVERY DATA

Zone	Present operator and well name	Original operator and well name	Sec. T. & R.	B & M	Initial daily production Oil (bbl)	Initial daily production Gas (Mcf)	Date of completion
Tulare	Texfel Petroleum Corp. "McNeil" 2	Charles R. Jacobson "Jacobson-McNeil" 2	18 30S 22E	MD	65	0	Jul 1948
Olig	Standard Oil Co. of Calif. No. 113	Same as present	7 30S 22E	MD	28	0	Jan 1944
Antelope	Standard Oil Co. of Calif. No. 34	Same as present	17 30S 22E	MD	57	0	Jan 1964
Carneros	Standard Oil Co. of Calif. "Spreckels" 555	Same as present	16 30S 22E	MD	556	225	Jul 1964
Phacoides	Standard Oil Co. of Calif. "Spreckels" 555	Same as present	16 30S 22E	MD	541	300	Jul 1964
Oceanic	Standard Oil Co. of Calif. "Jacobson" 581	Same as present	18 30S 22E	MD	20	6,700	Jan 1965
Point of Rocks	Standard Oil Co. of Calif., Opr. "Jacobson" 572R	Standard Oil Co. of Calif. "Jacobson" 572	18 30S 22E	MD	20	N.A.	May 1965

Remarks: Initial production from the Point of Rocks zone was estimated because it was commingled with production from the Phacoides zone.

DEEPEST WELL DATA

Present operator and well name	Original operator and well name	Date started	Sec. T. & R.	B & M	Depth (feet)	At total depth Strata	At total depth Age
Standard Oil Co. of Calif., Opr. "Jacobson" 572R	Standard Oil Co. of Calif. "Jacobson" 572	Jan 1965	18 30S 22E	MD	10,864	Point of Rocks	late Eo.

PRODUCING ZONES

Zone	Average depth (feet)	Average net thickness (feet)	Geologic Age	Geologic Formation	Oil gravity (°API) or Gas (btu)	Salinity of zone water gr/gal	Class BOPE required
Tulare	650	400	Pleistocene	Tulare	11 - 25	70 - 420	None
Olig	800	500	late Miocene	Monterey	15	N.A.	None
Antelope	3,600	2,400	late Miocene	Monterey	22 - 28	1,430	III
Carneros	6,500	100	early Miocene	Temblor	34 - 40	1,230	IV
Phacoides	790	300	early Miocene	Temblor	35	570	IV
Oceanic	8,300	125	Oligocene	Tumey	36	680	IV
Point of Rocks	9,100	1,400	late Eocene	Kreyenhagen	24	1,330	IV

PRODUCTION DATA (Jan. 1, 1973) (Dry gas production data not included - see Remarks)

1972 Production Oil (bbl)	1972 Production Net gas (Mcf)	1972 Production Water (bbl)	1972 Proved acreage	1972 Average number producing wells	Cumulative production Oil (bbl)	Cumulative production Gas (Mcf)	Peak oil production Barrels	Peak oil production Year	Total number of wells Drilled	Total number of wells Completed	Maximum proved acreage
3,205,415	10,018,295	4,282,081	1,920	277	42,662,875	119,541,711	7,356,272	1966	391	346	1,930

STIMULATION DATA (Jan. 1, 1973)

Type of project	Date started	Cumulative injection - Water, bbl; Gas, Mcf; Steam, bbl (water equivalent)	Maximum number of wells used for injection
Cyclic-steam	1964	4,672,042	154
Steam flood	1971	308,931	2
Water flood	1970	2,098,343	2

SPACING ACT: Applies

BASE OF FRESH WATER: None

CURRENT CASING PROGRAM: Tulare & Olig: 7" cem. above zone; 5 1/2" liner landed through zone. Antelope: 10 3/4" cem. 500; 7" cem. above zone; 5 1/2" liner landed through zone. Carneros & deeper: 10 3/4" cem. through shallow oil zone; 7" cem. through zone.

METHOD OF WASTE DISPOSAL: Evaporation and percolation sumps.

REMARKS: A total of 1,232,460 Mcf of dry gas has been produced from 5 wells completed in the Amnicola sand of the Tulare zone at structurally high locations. The gas has a heat value of 997 Btu. Although no BOPE is required for Tulare zone wells, extra care should be used because of the localized occurrences of low pressure gas. An in-situ combustion project was started in the Tulare zone in 1966 and discontinued in 1970.

REFERENCES: Bertholf, H.W., Northeast Area of McKittrick Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 48, No. 1 (1962).

Weddle, J.R., Northeast Area of McKittrick Oil Field: Calif. Div. of Oil and Gas, Summary of Operations--Calif. Oil Fields, Vol. 51, No. 2 (1965).

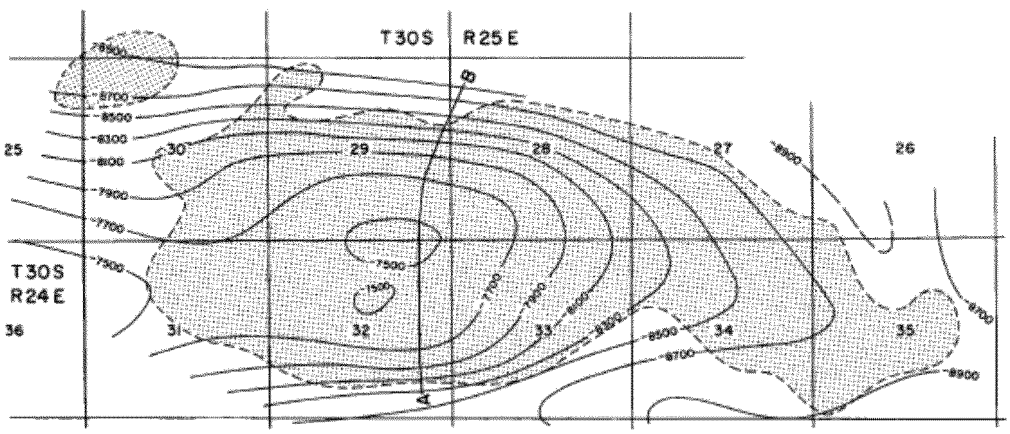
McKittrick Field Geologic Data, Northeast Area:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

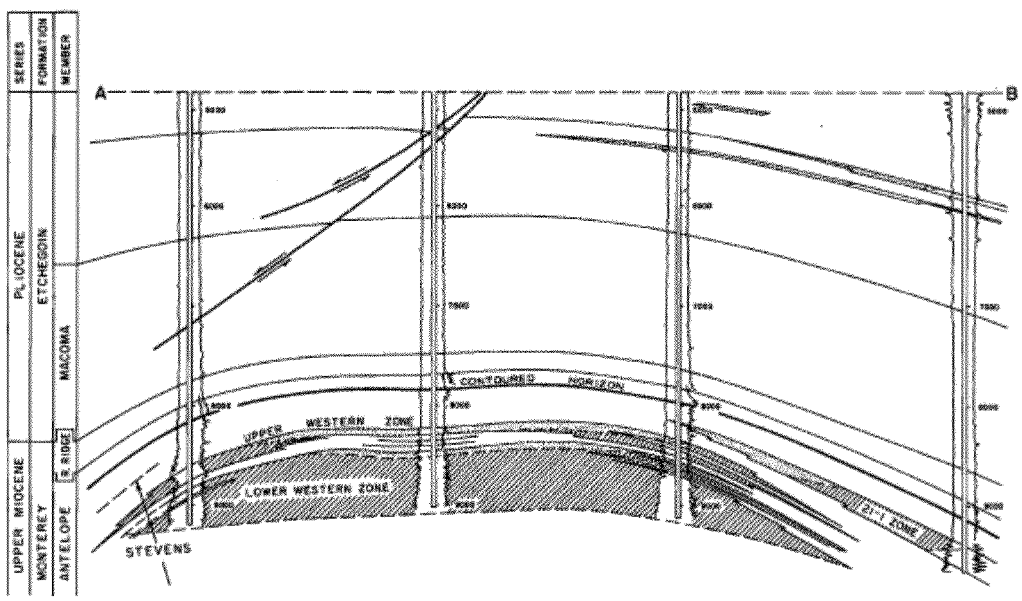
Exhibit 12

North Coles Levee Geologic Data

NORTH COLES LEVEE OIL FIELD



CONTOURS ON N ELECTRIC LOG MARKER



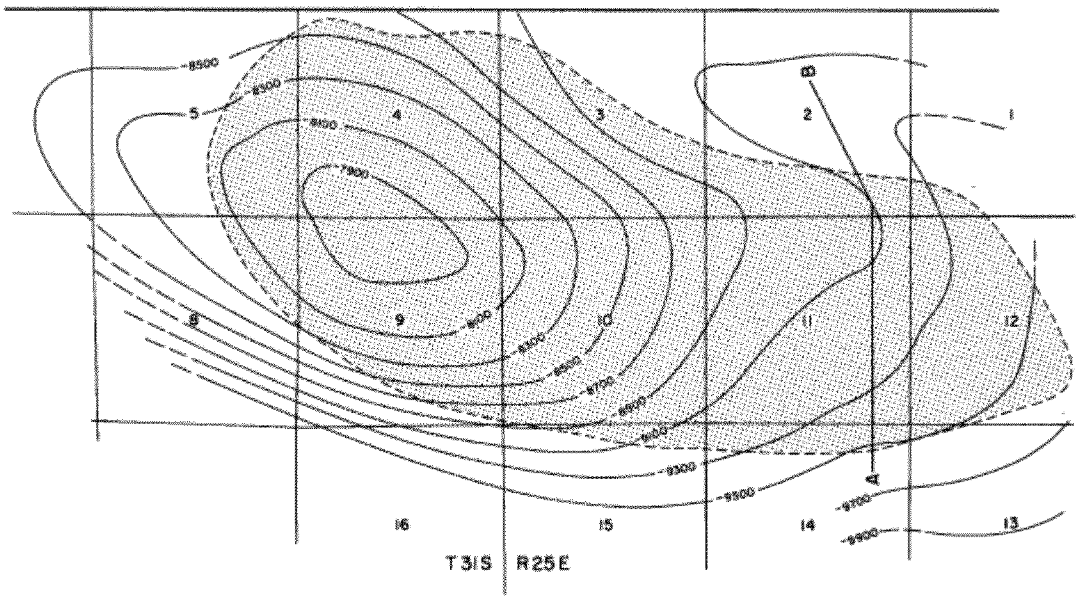
North Coles Levee Field Geologic Data

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

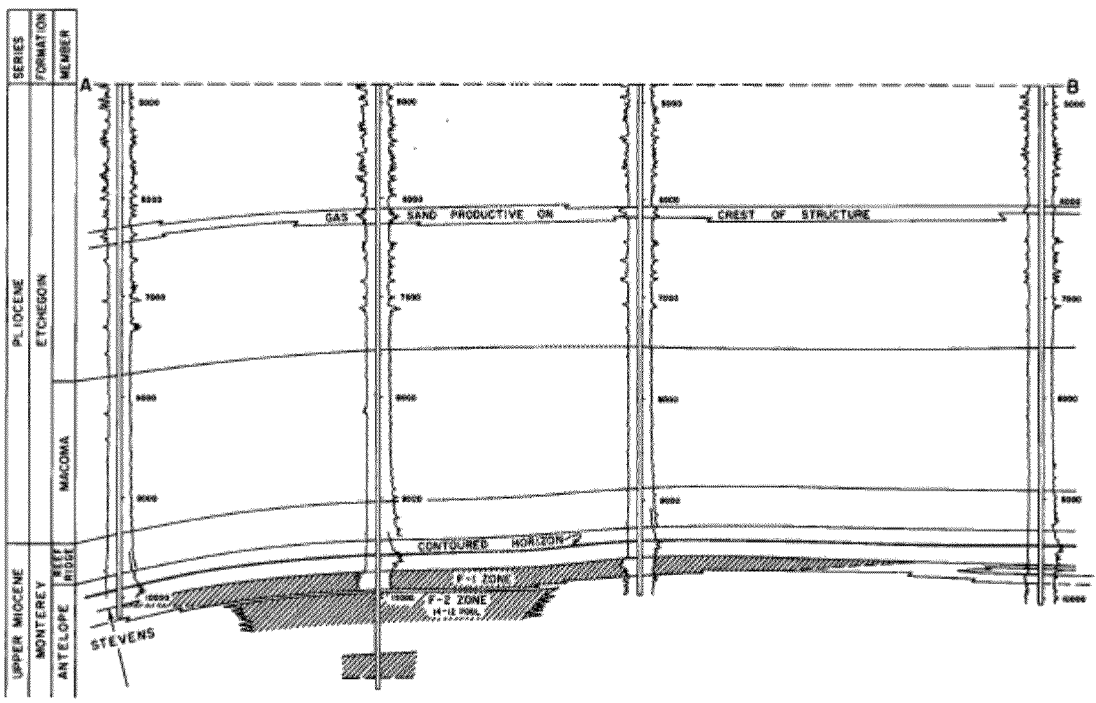
Exhibit 13

South Coles Levee Geologic Data

SOUTH COLES LEVEE OIL FIELD



CONTOURS ON N ELECTRIC LOG MARKER



South Coles Levee Field Geologic Data:

1973 *California Oil and Gas Fields* (Pre-Primacy Agreement)

Exhibit 14

Class I Non-Hazardous and Class II Tulare Injection Information

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

RECEIVED BY
FEB 26 2001
HEALTH, ENVIRONMENT & SAFETY

FEB 21 2001

CERTIFIED MAIL P 104 939 671
RETURN RECEIPT REQUESTED

Elk Hills Project Job #C-10200 Date 8/25/01		
Name	Action	Info
J. Rowley		
J. Bisse	✓	
J. Hanlo		
J. McCrank		
W. Moran		
T. Jennings	✓	
J. Hogenson	✓	
L. Padilla		
O. Champion		
Y. Law	✓	
T. PERRINO	✓	
C. PEREZ	✓	
J. HOGENSON	✓	
R. KELLY		✓
Comments:		

PERHAPS SOME OF YOU HAVE THIS ALREADY NOTE INJECTION LIMIT ON PAGE 9 OF 16. ALSO DESIGN REQUIREMENTS + PRE-OPERATION REQUIREMENTS. LETS DISCUSS. - JOE BISSE 6/25/01

Dennis Champion, P.E.
Project Permitting Manager
Elk Hills Power, LLC.
P.O. Box 1001
Tupman, California 93276-1001

Katherine S. Poole
Adams Broadwell Joseph & Cardozo
651 Gateway Boulevard, Suite 900
South San Francisco, CA 94080

Dear Mr. Champion and Ms. Poole:

Enclosed (original to Dennis Champion, copy to Katherine Poole) is the Underground Injection Control ("UIC") Class I Nonhazardous Waste Injection Permit No. CA200002, which is being issued to Elk Hills Power, LLC ("Elk Hills") authorizing injection activities at the Elk Hills Power Project in Kern County, California. Please note that authorization to drill and construct the wells will be issued after the requirements of financial responsibility are met. Authorization to inject will be issued after requirements specified in the permit are met.

The staff at the Environmental Protection Agency, Region 9 ("EPA") has reviewed the UIC permit application and associated documents relating to the Elk Hills Power Project, and has prepared this final permit in accordance with the Safe Drinking Water Act ("SDWA").

EPA published a public notice of the preparation of the draft permit on July 20, 2000 and sought comments on the draft permit from interested persons. During the public comment period, EPA received comments submitted on behalf of the California Unions for Reliable Energy. After considering all expressed views of the commenter, EPA prepared a final permit that does not differ substantially from the draft permit, in accordance with the SDWA and 40 C.F.R. Part 124. We have also enclosed a copy of EPA's "Response To Comments" for your reference.

EPA Transmittal Letter: Class I Non-Hazardous Waste Injection Permit No. CAF200002

The UIC permit is issued upon the date of signature on the permit and shall become effective 30 days thereafter, unless there is an appeal of this final permit decision to the Environmental Appeals Board. Pursuant to 40 C.F.R. § 124.19, an appeal must be taken within 30 days of the service of notice of EPA's action (i.e., the date of this letter). Furthermore, a petition for review must state the reasons supporting review, including a showing that the challenged permit condition is based on: (1) a finding of fact or conclusion of law which is clearly erroneous; or (2) an exercise of discretion or an important policy consideration which the Environmental Appeals Board should, in its discretion, review. 40 C.F.R. § 124.19.

If you have any questions, please contact George Robin of my staff at (415) 744-1819.

Sincerely,

Laura Tom-Bose

Laura Tom Bose
Manager, Groundwater Office

Enclosures

EPA Transmittal Letter: Class I Non-Hazardous Waste Injection Permit No. CA200002

EPA Region IX
Underground Injection Control Program
Class I Nonhazardous Waste Injection Draft Permit No. CA200002

Response To Comments

February 16, 2001

Comment No. 6:
The commenter believes two USDWs will be potentially affected by the injection operation, in violation of 40 CFR § 144.12.
Response No. 6:
After review of the existing records, EPA has made the determination that the Tulare formation within the Area of Review is an exempted aquifer. As such, the prohibitions of 40 CFR §144.12(a) do not apply to the Tulare formation within the Area of Review. Furthermore, injection will be confined to the intended injection zone and no USDWs will be impacted by the permitted underground injection activities.

Excerpt of Responses to Comments in the EPA Transmittal Letter:

Class I Non-Hazardous Waste Injection Permit No. CA200002

Underground Injection Control Program

PERMIT

Class I Nonhazardous Waste Injection
Permit No. CA200002

Well Names: 15-18G and 35-18G
Kern County, California

Issued to:

Elk Hills Power, LLC
P.O. Box 1001
Tupman, CA 93276

Class I Non-Hazardous Waste Injection Permit No. CA200002: Original Permit

PART I. AUTHORIZATION TO INJECT

Pursuant to the Underground Injection Control (UIC) regulations of the U.S. Environmental Protection Agency (EPA) codified at Title 40 of the Code of Federal Regulations (CFR), Parts 124, 144, 146, 147, and 148,

Elk Hills Power, LLC
P.O. Box 1001
Tupman, CA 93276

is hereby authorized to operate a Class I nonhazardous waste injection well facility with two injection wells. The wells are to be located at Section 18, T.31S., R.24E., NW ¼ Sec., 1100 feet FWL, 2750 feet FSL in Kern County, California.

Authorization to drill and construct the wells will be issued by EPA after the requirements of Financial Responsibility in Part II.F of this permit have been met. Authorization to inject will be issued after the requirements of Part II., Section C.1 of this permit have been met. Injection will be authorized into the Tulare formation for the purpose of disposal of industrial nonhazardous fluids produced during the operation of an electrical power generating plant. The types of fluids to be injected are limited to cooling tower blowdown wastewater (using source water from West Kern Water District); plant area wash wastewater; demineralizer resins regeneration wastewater; plant and equipment drains wastewater; filter backwash wastewater; and non-oil-contaminated storm runoff wastewater.

All conditions set forth herein are based on Title 40 Parts 124, 144, 146, 147 and 148 of the Code of Federal Regulations.

This permit consists of 16 pages and includes all items listed in the Table of Contents. Further, it is based upon representations made by Elk Hills Power, LLC (the permittee). It is the responsibility of the permittee to read and understand all provisions of this permit.

This permit and the authorization to inject are issued for a period of up to ten (10) years unless terminated under the conditions set forth in Part III, Section B of this permit.

Issued this 21st day of February, 2001

This permit shall become effective thirty (30) days after the date of issuance.

John Ong for
Alexis Strauss, Director
Water Division, EPA Region IX

Class I Non-Hazardous Waste Injection Permit No. CA200002: Original Permit

Underground Injection Control Program

PERMIT

Class I Nonhazardous Waste Injection
Permit No. CA200002

Well Names: 25-18G, 35-18G, 25A-18G and 35A-18G
Kern County, California

Issued to:

Elk Hills Power, LLC
P.O. Box 460
4026 Skyline Road
Tupman, CA 93276

Excerpts from the Modified Elk Hills Power Class I Non-Hazardous UIC Permit for the Tulare Formation in the Elk Hills Field, Dated June 3, 2004

PART I. AUTHORIZATION TO INJECT

Pursuant to the Underground Injection Control (UIC) regulations of the U.S. Environmental Protection Agency (EPA) codified at Title 40 of the Code of Federal Regulations (CFR), Parts 124, 144, 146, 147, and 148,

Elk Hills Power, LLC
P.O. Box 460
4026 Skyline Road
Tupman, CA 93276

is hereby authorized to operate a Class I nonhazardous waste injection well facility with four injection wells. The wells are to be located at Section 18, T.31S., R.24E., NW ¼ Sec. in Kern County, California.

Authorization to drill and construct the wells will be issued by EPA after the requirements of Financial Responsibility in Part II.F of this permit have been met. Authorization to inject will be issued after the requirements of Part II., Section C.1 of this permit have been met. Injection will be authorized into the Tulare formation for the purpose of disposal of industrial nonhazardous fluids produced during the operation of an electrical power generating plant. The types of fluids to be injected are limited to turbine wash wastewater, cooling tower blowdown wastewater (using source water from West Kern Water District); plant area wash wastewater; demineralizer resins regeneration wastewater; plant and equipment drains wastewater; filter backwash wastewater; and non-oil-contaminated storm runoff wastewater.

All conditions set forth herein are based on Title 40 Parts 124, 144, 146, 147 and 148 of the Code of Federal Regulations.

This permit consists of 16 pages and includes all items listed in the Table of Contents. Further, it is based upon representations made by Elk Hills Power, LLC (the permittee). It is the responsibility of the permittee to read and understand all provisions of this permit.

This permit and the authorization to inject are issued for a period of up to ten (10) years unless terminated under the conditions set forth in Part III, Section B of this permit.

Original permit issued on 02/21/01
Modified this 3rd day of June, 2004

Alexis Strauss

Alexis Strauss, Director
Water Division, EPA Region IX

Excerpts from the Modified Elk Hills Power Class I Non-Hazardous UIC Permit for the Tulare Formation in the Elk Hills Field, Dated June 3, 2004

STATE OF CALIFORNIA—RESOURCES AGENCY

EXEMPTED & NOT EXEMPTED ZONES

EDMUND G. BROWN JR.

DEPARTMENT OF CONSERVATION
DIVISION OF OIL AND GAS
[illegible] STOCKDALE HWY., SUITE #417
[illegible]SFIELD, CALIFORNIA 93309
(805) 322-4031

Gentlemen:

As requested, attached is a list of those zones exempted and not exempted, under Federal U.I.C. regulations, for the reinjection of produced oil field water (U.I.C Class II injection wells). Please note that those wells disposing of fluids other than produced water are not included in this category. Such wells and the corresponding zone exemption status are the jurisdiction of the Regional Water Quality Control Board.

It should be noted further that a zone "exemption" does not necessarily include the entire vertical or lateral limits of the formation. In all cases, the maximum zone exemption is restricted to the current productive limits of the field. At a minim the exemption may include only specific intervals within a zone or a certain area of a given field. These conditions are subject to change at any time without prio contact. The attached lists are to be used solely as a guideline for initial consideration for project application. If more detailed information is required plea contact the respective Division of Oil & Gas office.

Yours truly,

A. G. Hluza
Deputy Supervisor

By David Mitchell
David Mitchell
Associate Oil & Gas Engineer

Excerpt of DOGGR letter with attached list of aquifer exemptions in Kern, Tulare, and Inyo Counties

U.I.C. EXEMPT AQUIFERS FOR CLASS II INJECTION [illegible]

(Kern, Tulare, and Inyo Counties)

Field	Zone
Ant Hill	Olcese
Antelope Hills	Button Bed
Asphalto	Stevens
Bellevue	Etchegoin
Bellevue, West	Tulare
	Etchegoin
Belgian Anticline	Oceanic
Belridge, North	Tulare
	64
Belridge, South	Tulare
	Etchegoin
	Diatomite
Blackwells Corner	Agua
Buena Vista	Tulare?
	Etchegoin (27B)
	Etchegoin (99-9D)
	Gusher
	Top Oil
	Calitroleum
	Sub-Calitroleum
	Sub-Scalez
	Wilhelm
Cal Canal	Tulare
	San Joaquin
Canal	Etchegoin
	Stevens
Canfield Ranch	Etchegoin
Cienega Canyon	Temblor
Coles Levee, North	Tulare
	21-1
	Upper Western
	San Joaquin
	Scales
	Etchegoin
	Main Western
Coles Levee, South	Tulare
	San Joaquin
	Stevens
Cymric	Reef Ridge
	Tulare
	Phacoides
Deer Creek	Santa Margarita
Devils Den	Alluvium
	Temblor
Edison	Olcese
	Main Wicker
	Santa Margarita
	Schist
	Chanac
Elk Hills	Stevens
	Western 31S
	Main Body B
	24Z Sand
	Northwest
	Tulare
	Sub-Scalez

Partial list of exempt aquifers in Kern, Tulare, and Inyo Counties, showing the Tulare Formation in the Elk Hills field as an exempt aquifer.

STATE OF CALIFORNIA--THE RESOURCES AGENCY GRAY DAVIS, Governor

DEPARTMENT OF CONSERVATION

4800 STOCKDALE HWY, SUITE 417
BAKERSFIELD, CALIFORNIA 93309
(661) 322-4031
FAX: (661) 861-0279

RECEIVED
SEP 20 2002
BY:

BK10901817
IRON MOUNTAIN

September 19, 2002

Mr. Bruce A. Macdonald
Occidental of Elk Hills, Inc.
P.O. Box 1001
Tupman, CA 93276

WATER DISPOSAL PROJECT PERMIT EXPANSION
Elk Hills Field
Tulare Zone
Sec. 24, T.30S., R.22E
Sec. 12,13, T.31S., R.23E
Sec. 7,8,10,17,18, T.31S., R.24E

Project Code: 22800002
Max. Permitted Volume: 230,000 B/D
Max. Permitted Well(s): 26
Note: Notify this office if either of these values are exceeded.

Dear Mr. Macdonald:

The expansion of the project designated above is approved provided:

1. Notices of intention to drill, redrill, deepen, rework, or abandon, on current Division forms (OG105, OG107, OG108) shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

2. This office shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressures. Such changes shall not be carried out without Division approval.

3. A monthly Injection Report shall be filed with this Division on our Form OG110B on or before the last day of each month, for the preceding month, showing the amount of fluid injected, and surface pressure required for each injection well.

4. A chemical analysis of the fluid to be injected shall be made and filed with this Division whenever the source of injection fluid is changed, or as requested by this office. ALL FLUIDS MUST MEET CLASS II CRITERIA.

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

5. All fluid sampling and analyses required by this Division are done in accordance with the provisions of the Division's Quality Assurance Program. Please refer to the Division's "Notice to Oil and Gas Operators" dated: November 17, 1986.

6. An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

7. All injection wells shall be equipped with tubing and packer set immediately above the approved zone of injection upon completion or recompletion, unless a variance to this requirement has been granted by this office.

8. A Standard Annular Pressure Test (SAPT) shall be run, as outlined in the Notice to Operators dated 1/9/90, prior to injecting into any well(s) being drilled or reworked for the purpose of injection and every five years thereafter or as requested by the Division. The Division shall be notified to witness such tests.

9. Injection profile surveys for all fluid injection wells shall be filed with the Division within three (3) months after injection has commenced, once every year thereafter, after any significant anomalous rate or pressure change, or as requested by the Division, to confirm that the injection fluid is confined to the proper zone or zones. This monitoring schedule may be modified by the district deputy. This office shall be notified before such surveys are made, as surveys may be witnessed by the Division inspector.

10. Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, of loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

11. The maximum allowable injection pressure gradient is limited to 0.7 psi per foot of depth as measured at the top perforation. Prior to any sustained injection above this gradient, rate-pressure tests shall be made. The test shall begin at the hydrostatic gradient of the injection fluid to be used and shall continue until either the intended maximum injection pressure is reached or until the formation fractures, whichever occurs first. These tests shall be witnessed, unless otherwise instructed, and the test results submitted to this Division for approval.

12. All injection piping, valves, and facilities shall meet or exceed design standards for the injection pressure and shall be maintained in a safe and leak-free condition.

13. Any remedial work needed as a result of this project on idle, abandoned, or deeper zone wells in order to protect oil, gas, or freshwater zones, shall be the responsibility of the project operator.

14. Additional data will be supplied upon the request of the Division.

NOTE: Monthly injection rate vs. pressure graphs for the 5 newly proposed disposal wells must be submitted to this office every 6 months.

Sincerely,

Randy Adams

for Hal Bopp
Deputy Supervisor
Division of Oil, Gas, and Geothermal Resources

cc: RWQCB
UIC file

uic\wp\wd

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

STATE OF CALIFORNIA--THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF CONSERVATION

4800 STOCKDALE HWY, SUITE 417
BAKERSFIELD, CALIFORNIA 93309
(661) 322-4031
FAX: (661) 861-0279

RECEIVED
FEB 19 2004
BY: [illegible]

February 18, 2004

BK10901810
IRON MOUNTAIN

Mr. Robert A. Joseph
Occidental of Elk Hills, Inc.
P.O. Box 1001
Tupman, CA 93276

WATER DISPOSAL PROJECT PERMIT
Elk Hills Field
Tulare Zone
Sec. 24, T.30S., R.22E
Sec. 12,13, T.31S., R.23E
Sec. 7,8,10,17,18, T.31S., R.24E

Project Code: 22800002
Max. Permitted Volume: 230,000 B/D
Max. Permitted Well(s): 36
Note: Notify this office if either of these values are exceeded.

Dear Mr. Joseph:

The expansion of the project designated above is approved provided:

1. Notices of intention to drill, redrill, deepen, rework, or abandon, on current Division forms (OG105, OG107, OG108) shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

2. This office shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressures. Such changes shall not be carried out without Division approval.

3. A monthly Injection Report shall be filed with this Division on our Form OG110B on or before the last day of each month, for the preceding month, showing the amount of fluid injected, and surface pressure required for each injection well.

4. A chemical analysis of the fluid to be injected shall be made and filed with this Division whenever the source of injection fluid is changed, or as requested by this office. ALL FLUIDS MUST MEET CLASS II CRITERIA.

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

5. All fluid sampling and analyses required by this Division are done in accordance with the provisions of the Division's Quality Assurance Program. Please refer to the Division's "Notice to Oil and Gas Operators" dated: November 17, 1986.

6. An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

7. All injection wells shall be equipped with tubing and packer set immediately above the approved zone of injection upon completion or recompletion, unless a variance to this requirement has been granted by this office.

8. A Standard Annular Pressure Test (SAPT) shall be run, as outlined in the Notice to Operators dated 1/9/90, prior to injecting into any well(s) being drilled or reworked for the purpose of injection and every five years thereafter or as requested by the Division. The Division shall be notified to witness such tests.

9. Injection profile surveys for all fluid injection wells shall be filed with the Division within three (3) months after injection has commenced, once every year thereafter, after any significant anomalous rate or pressure change, or as requested by the Division, to confirm that the injection fluid is confined to the proper zone or zones. This monitoring schedule may be modified by the district deputy. This office shall be notified before such surveys are made, as surveys may be witnessed by the Division inspector.

10. Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, of loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

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Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

12. All injection piping, valves, and facilities shall meet or exceed design standards for the injection pressure and shall be maintained in a safe and leak-free condition.

13. Any remedial work needed as a result of this project on idle, abandoned, or deeper zone wells in order to protect oil, gas, or freshwater zones, shall be the responsibility of the project operator.

14. Additional data will be supplied upon the request of the Division.

Sincerely,

Randy Adams

Randy Adams
Deputy Supervisor
Division of Oil, Gas, and Geothermal Resources

cc: RWQCB
UIC file

uic\wp\wd

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

STATE OF CALIFORNIA--THE RESOURCES AGENCY GRAY DAVIS, Governor
DEPARTMENT OF CONSERVATION
4800 STOCKDALE HWY, SUITE 417
BAKERSFIELD, CALIFORNIA 93309
(661) 322-4031
FAX: (661) 861-0279

September 19, 2002

RECEIVED
SEP 20 2002
BY: JN

BK10901817
IRON MOUNTAIN

Mr. Bruce A. Macdonald
Occidental of Elk Hills, Inc.
P.O. Box 1001
Tupman, CA 93276

WATER DISPOSAL PROJECT PERMIT EXPANSION
Elk Hills Field
Tulare Zone
Sec. 24, T.30S., R.22E
Sec. 12,13, T.31S., R.23E
Sec. 7,8,10,17,18, T.31S., R.24E

Project Code: 22800002
Max. Permitted Volume: 230,000 B/D
Max. Permitted Well(s): 26
Note: Notify this office if either of these values are exceeded.

Dear Mr. Macdonald:

The expansion of the project designated above is approved provided:

1. Notices of intention to drill, redrill, deepen, rework, or abandon, on current Division forms (OG105, OG107, OG108) shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

2. This office shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressures. Such changes shall not be carried out without Division approval.

3. A monthly Injection Report shall be filed with this Division on our Form OG110B on or before the last day of each month, for the preceding month, showing the amount of fluid injected, and surface pressure required for each injection well.

4. A chemical analysis of the fluid to be injected shall be made and filed with this Division whenever the source of injection fluid is changed, or as requested by this office. ALL FLUIDS MUST MEET CLASS II CRITERIA.

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

5. All fluid sampling and analyses required by this Division are done in accordance with the provisions of the Division's Quality Assurance Program. Please refer to the Division's "Notice to Oil and Gas Operators" dated: November 17, 1986.

6. An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

7. All injection wells shall be equipped with tubing and packer set immediately above the approved zone of injection upon completion or recompletion, unless a variance to this requirement has been granted by this office.

8. A Standard Annular Pressure Test (SAPT) shall be run, as outlined in the Notice to Operators dated 1/9/90, prior to injecting into any well(s) being drilled or reworked for the purpose of injection and every five years thereafter or as requested by the Division. The Division shall be notified to witness such tests.

9. Injection profile surveys for all fluid injection wells shall be filed with the Division within three (3) months after injection has commenced, once every year thereafter, after any significant anomalous rate or pressure change, or as requested by the Division, to confirm that the injection fluid is confined to the proper zone or zones. This monitoring schedule may be modified by the district deputy. This office shall be notified before such surveys are made, as surveys may be witnessed by the Division inspector.

10. Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, of loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

11. The maximum allowable injection pressure gradient is limited to 0.7 psi per foot of depth as measured at the top perforation. Prior to any sustained injection above this gradient, rate-pressure tests shall be made. The test shall begin at the hydrostatic gradient of the injection fluid to be used and shall continue until either the intended maximum injection pressure is reached or until the formation fractures, whichever occurs first. These tests shall be witnessed, unless otherwise instructed, and the test results submitted to this Division for approval.

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

12. All injection piping, valves, and facilities shall meet or exceed design standards for the injection pressure and shall be maintained in a safe and leak-free condition.

13. Any remedial work needed as a result of this project on idle, abandoned, or deeper zone wells in order to protect oil, gas, or freshwater zones, shall be the responsibility of the project operator.

14. Additional data will be supplied upon the request of the Division.

NOTE: Monthly injection rate vs. pressure graphs for the 5 newly proposed disposal wells must be submitted to this office every 6 months.

Sincerely,

Randy Adams

for Hal Bopp
Deputy Supervisor
Division of Oil, Gas, and Geothermal Resources

cc: RWQCB
UIC file

uic\wp\wd

Approval of Class II UIC Project #22800002 Expansion:

Tulare Formation in the Elk Hills Field

STATE OF CALIFORNIA--THE RESOURCES AGENCY
ARNOLD SCHWARZENEGGER, Governor
DEPARTMENT OF CONSERVATION
4800 STOCKDALE HWY, SUITE 417
BAKERSFIELD, CALIFORNIA 93309
(661) 322-4031
FAX: (661) 861-0279

RECEIVED
APR 08 2004
BY:

April 7, 2004

Mr. Robert A. Joseph
Occidental of Elk Hills, Inc.
P.O. Box 1001
Tupman, CA 93276

WATER DISPOSAL PROJECT PERMIT
Elk Hills Field
L. Tulare Zone
Sec. 27,28, T.30S., R.23E

Project Code: 22800022
Max. Permitted Volume: 250,000 B/D
Max. Permitted Well(s): 32
Note: Notify this office if either of these values are exceeded.

Dear Mr. Joseph:

The initiation of the project designated above is approved provided:

1. Notices of intention to drill, redrill, deepen, rework, or abandon, on current Division forms (OG105, OG107, OG108) shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

2. This office shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressures. Such changes shall not be carried out without Division approval.

3. A monthly Injection Report shall be filed with this Division on our Form OG110B on or before the last day of each month, for the preceding month, showing the amount of fluid injected, and surface pressure required for each injection well.

4. A chemical analysis of the fluid to be injected shall be made and filed with this Division whenever the source of injection fluid is changed, or as requested by this office. ALL FLUIDS MUST MEET CLASS II CRITERIA.

Approval of Class II UIC Project #22800022:

Tulare Formation in the Elk Hills Field

5. All fluid sampling and analyses required by this Division are done in accordance with the provisions of the Division's Quality Assurance Program. Please refer to the Division's "Notice to Oil and Gas Operators" dated: November 17, 1986.

6. An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

7. All injection wells shall be equipped with tubing and packer set immediately above the approved zone of injection upon completion or recompletion, unless a variance to this requirement has been granted by this office.

8. A Standard Annular Pressure Test (SAPT) shall be run, as outlined in the Notice to Operators dated 1/9/90, prior to injecting into any well(s) being drilled or reworked for the purpose of injection and every five years thereafter or as requested by the Division. The Division shall be notified to witness such tests.

9. Injection profile surveys for all fluid injection wells shall be filed with the Division within three (3) months after injection has commenced, once every year thereafter, after any significant anomalous rate or pressure change, or as requested by the Division, to confirm that the injection fluid is confined to the proper zone or zones. This monitoring schedule may be modified by the district deputy. This office shall be notified before such surveys are made, as surveys may be witnessed by the Division inspector.

10. Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, of loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

11. The maximum allowable injection pressure gradient is limited to 0.7 psi per foot of depth as measured at the top perforation. Prior to any sustained injection above this gradient, rate-pressure tests shall be made. The test shall begin at the hydrostatic gradient of the injection fluid to be used and shall continue until either the intended maximum injection pressure is reached or until the formation fractures, whichever occurs first. These tests shall be witnessed, unless otherwise instructed, and the test results submitted to this Division for approval.

12. All injection piping, valves, and facilities shall meet or exceed design standards for the injection pressure and shall be maintained in a safe and leak-free condition.

13. Any remedial work needed as a result of this project on idle, abandoned, or deeper zone wells in order to protect oil, gas, or freshwater zones, shall be the responsibility of the project operator.

14. Additional data will be supplied upon the request of the Division.

NOTE: Your proposed injectors within 'Phase 1' on the attached map are approved for injection without any prior remedial work. However, the injectors within 'Phase 2' are not permitted to inject until certain remedial work is performed on selected wells within the 1/4 mile area of review. The remedial work required shall consist of perforating the casing at the top of the proposed injection zone and squeezing a minimum of 100 lineal feet of cement outside of casing. Prior to commencement of injection into 'Phase 2' wells, the wells requiring remedial work, as shown on the attached map, are 366-27R, 378-27R, 88-27R, 28-27R, and 374-27R. In addition, within 1 year of commencement of injection into 'Phase 2' wells, the following wells shall be remediated: 356-27R, 368-27R, 314-27R, and 316-27R.

Sincerely,

Randy Adams

Randy Adams
Deputy Supervisor
Division of Oil, Gas, and Geothermal Resources

cc: RWQCB
UIC file

uic\wp\wd

Approval of Class II UIC Project #22800022:

Tulare Formation in the Elk Hills Field

DEPARTMENT OF CONSERVATION

DIVISION OF OIL, GAS AND GEOTHERMAL RESOURCES

4800 Stockdale Highway • Suite 417 • BAKERSFIELD, CALIFORNIA 93309
PHONE 661 / 322-4031 • FAX 661 / 861-0279 • WEBSITE conservation.ca.gov/DOG

February 24, 2009

Occidental of Elk Hills, Inc. (O0[illegible])
Mr. Alan E. White
P.O. Box 1001
Tupman, CA 93276

RECEIVED
FEB 26 2009
By

[illegible]TER DISPOSAL PROJECT
[illegible] Hills Field
TULARE Zone
[illegible]. 20,21,27,28, T.30S., R.23E.

Project Code: 22800022
Max. Permitted Volume: 550,000 B/D
Max. Permitted Well(s): 77

Dear Mr. White:

The expansion of the project designated above is approved provided:

1. Notices of intention to drill, redrill, deepen, rework, or abandon, on current Division forms (OG105, OG107, OG108) shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

2. This office shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressures. Such changes shall not be carried out without Division approval.

3. A monthly Injection Report shall be filed with this Division on our Form OG110B on or before the last day of each month, for the preceding month, showing the amount of fluid injected, and surface pressure required for each injection well.

4. A chemical analysis of the fluid to be injected shall be made and filed with this Division whenever the source of injection fluid is changed, or as requested by this office. ALL FLUIDS MUST MEET CLASS II CRITERIA.

The Department of Conservation's mission is to balance today's needs with tomorrow's challenges and foster intelligent, sustainable, and efficient use of California's energy, land, and mineral resources.

Approval of Class II UIC Project #22800022: Tulare Formation in the Elk Hills Field

5. All fluid sampling and analyses required by this Division are done in accordance with the provisions of the Division's Quality Assurance Program. Please refer to the Division's "Notice to Oil and Gas Operators" dated: November 17, 1986.

6. An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

7. All injection wells shall be equipped with tubing and packer set immediately above the approved zone of injection upon completion or recompletion, unless a variance to this requirement has been granted by this office.

8. A Standard Annular Pressure Test (SAPT) shall be run, as outlined in the Notice to Operators dated 1/9/90, prior to injecting into any well(s) being drilled or reworked for the purpose of injection or as requested by the Division. The Division shall be notified to witness such tests.

9. Injection profile surveys for all fluid injection wells shall be filed with the Division within three (3) months after injection has commenced, once every year thereafter, after any significant anomalous rate or pressure change, or as requested by the Division, to confirm that the injection fluid is confined to the proper zone or zones. This monitoring schedule may be modified by the district deputy. This office shall be notified before such surveys are made, as surveys may be witnessed by the Division inspector.

10. Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, of loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

11. The maximum allowable injection pressure gradient is limited to **0.7 psi** per foot of depth as measured at the top perforation. Prior to any sustained injection above this gradient, rate-pressure tests shall be made. The test shall begin at the hydrostatic gradient of the injection fluid to be used and shall continue until either the intended maximum injection pressure is reached or until the formation fractures, whichever occurs first. These tests shall be witnessed, unless otherwise instructed, and the test results submitted to this Division for approval.

Approval of Class II UIC Project #22800022: Tulare Formation in the Elk Hills Field

12. All injection piping, valves, and facilities shall meet or exceed design standards for the injection pressure and shall be maintained in a safe and leak-free condition.

13. Any remedial work needed as a result of this project on idle, abandoned, or deeper zone wells in order to protect oil, gas, or freshwater zones, shall be the responsibility of the project operator.

14. Additional data will be supplied upon the request of the Division.

NOTE: Your proposed injectors within "Phase 1" on the attached map are approved for injection without any prior remedial work. However, the injectors within "Phase 2" are not permitted to inject until certain remedial work is performed on selected wells within the ¼ mile area of review. The remedial work required shall consist of perforating the casing at the top of the proposed injection zone and squeezing a minimum of 100 lineal feet of cement outside the casing. Prior to commencement to injection into "Phase 2" disposal wells, the wells listed below shall be squeezed with cement:

Well Number	API Number	Sec.	Twn.	Rge.
366H-28R	029-27177	28	30S	23E
378-28R	029-27178	28	30S	23E
88-28R	029-27172	28	30S	23E
28-27R	029-27157	27	30S	23E
374-27R	029-27161	27	30S	23E

In addition, within 1 year of the commencement of injection into "Phase 2" wells, the following wells shall be squeezed with cement:

Well Number	API Number	Sec.	Twn.	Rge.
356H-28R	029-27176	28	30S	23E
368-28R	029-27172	28	30S	23E
314-26R	029-27130	26	30S	23E
314H-26R	029-27150	26	30S	23E
316-26R	029-27131	26	30S	23E

Sincerely,

RJ Adams

Randy Adams
Deputy Supervisor
Division of Oil, Gas, and Geothermal Resources

cc: RWQCB bm
UIC file
uic\wp\wd

Approval of Class II UIC Project #22800022: Tulare Formation in the Elk Hills Field

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Dist	Operator Name	Field Name	Lease	Well#	API	Well Stat	Pool	WellType	PWT Stat	S	T	R	BM	Op Cd	Field	Area	Area Name	Pool Name
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	62	03036537	Active	15	PM	Active	2	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	67N	03011868	Idle	15	PM	Cancelled	2	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	76NE	03012538	Active	15	PM	Cancelled	2	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	65NE	03039318	Active	15	PM	Active	2	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-6G	62W	03039325	Active	15	PM	Active	6	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-36S	18SW	03021705	Active	15	PM	Active	36	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-3G	72	03038933	Active	15	PM	Plugged	3	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-35S	61A	03012334	Active	15	PM	Active	35	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-35S	153	03010875	Idle	15	PM	Active	35	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-36S	38S	03011906	Active	15	PM	Active	36	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-26R	378A	02927156	Active	22	PM	Active	26	30S	23E	MD	00495	228	00	Any Area	Stevens (29R)
4	Occidental of Elk Hills, Inc.	Elk Hills	-10G	21	03018721	Active	15	PM	New	10	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-29S	27	02927432	Active	15	PM	New	29	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-30S	75	02952648	Active	15	PM	New	30	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-32S	422	03045586	Active	15	PM	New	32	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-32S	432	03045504	Active	15	PM	New	32	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-32S	454	03045506	Active	15	PM	New	32	30S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	67N	03011868	Idle	15	SC	Active	2	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-36R	35	02953051	Active	15	SC	New	36	30S	23E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-3G	18N	02976804	Idle	15	SF	Idle	3	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-4G	88E	02977021	Idle	15	SF	Active	4	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-10G	11N	02977142	Plugged	15	SF	Plugged	10	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-3G	18E	02976425	Plugged	15	SF	Plugged	3	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-17G	13WD	02967555	Active	15	WD	Active	17	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-17G	21WD	02961139	Idle	15	WD	Active	17	31S	24E	MD	00495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	61WD	02973098	Active	05	WD	Active	18	31S	24E	MD	00495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	71WD	02966694	Active	05	WD	Active	18	31S	24E	MD	00495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-24Z	13WD	02966704	Plugged	05	WD	Plugged	24	30S	22E	MD	00495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-24Z	22WD	02966705	Plugged	05	WD	Plugged	24	30S	22E	MD	00495	228	00	Any Area	Tulare

Tulare Wastewater Disposal Wells in the Elk Hills Field

4	Occidental of Elk Hills, Inc.	Elk Hills	-24Z	23WD	02964450	Plugged	05	WD	Plugged	24	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-24Z	224WD	02985278	Plugged	05	WD	Plugged	24	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	38WD	02985821	Active	05	WD	Active	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	48WD	02975252	Active	05	WD	Active	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	58WD	02985822	Active	05	WD	Active	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	68WD	02973097	Active	05	WD	Active	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	78WD	02966689	Plugged	05	WD	Plugged	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	88WD	02965495	Plugged	05	WD	Plugged	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-8G	38WD	02952871	Plugged	15	WD	Plugged	8	31S	24E	MD	O0495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-12B	22WD	03003324	Plugged	05	WD	Plugged	12	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-12B	66WD	03003239	Active	05	WD	Active	12	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-12B	86WD	03003240	Active	05	WD	Active	12	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	27WD	03002301	Active	05	WD	Active	7	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-7G	46WD	03004029	Plugged	15	WD	Plugged	7	31S	24E	MD	O0495	228	00	Any Area	Upper (Undifferentiated)
4	Bechtel Petro. Oper. Inc.	Elk Hills	-10G	56WD	02964448	Plugged	05	WD	Plugged	10	31S	24E	MD	W2500	228	00	Any Area	Tulare
4	Bechtel Petro. Oper. Inc.	Elk Hills	-18G	81WD	02964449	Plugged	05	WD	Plugged	18	31S	24E	MD	W2500	228	00	Any Area	Tulare
4	Bechtel Petro. Oper. Inc.	Elk Hills	-24Z	24WD	02965426	Plugged	05	WD	Plugged	24	30S	22E	MD	W2500	228	00	Any Area	Tulare
4	Bechtel Petro. Oper. Inc.	Elk Hills	-8G	18WD	02966663	Plugged	05	WD	Plugged	8	31S	24E	MD	W2500	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-26S	5-321WD	02945296	Active	13	WD	Active	26	30S	24E	MD	O0495	228	00	Any Area	Gas Zone
4	Occidental of Elk Hills, Inc.	Elk Hills	-2G	312	02927980	Active	24	WD	Active	2	31S	24E	MD	O0495	228	00	Any Area	Stevens (31S)
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	64WD	03019381	Plugged	05	WD	Plugged	18	31S	24E	MD	O0495	228	00	Any Area	Tulare

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Tulare Wastewater Disposal Wells in the Elk Hills Field

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Dist	Operator Name	Field Name	Lease	Well#	API	Well Stat	Pool	WellType	PWT Stat	S	T	R	BM	Op Cd	Field	Area	Area Name	Pool Name
4	Occidental of Elk Hills, Inc.	Elk Hills	-26S	381XWD	03017699	Active	14	WD	Active	26	30S	24E	MD	O0495	228	00	Any Area	4th Mya
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	54WD	03019512	Plugged	05	WD	Plugged	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-17G	351	03018768	Plugged	05	WD	Cancelled	17	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	57WD	03020255	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	67WD	03020256	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-8G	38WD	02952871	Plugged	05	WD	Plugged	8	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	37WD	03021009	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-35R	365H	02989926	Active	24	WD	Active	35	30S	23E	MD	O0495	228	00	Any Area	Stevens (31S)
4	Occidental of Elk Hills, Inc.	Elk Hills	-35R	354H	02988606	Active	24	WD	Active	35	30S	23E	MD	O0495	228	00	Any Area	Stevens (31S)
4	Occidental of Elk Hills, Inc.	Elk Hills	-36R	4-316H	02984800	Active	24	WD	Cancelled	36	30S	23E	MD	O0495	228	00	Any Area	Stevens (31S)
4	Occidental of Elk Hills, Inc.	Elk Hills	-35R	322A	02968193	Active	24	WD	Active	35	30S	23E	MD	O0495	228	00	Any Area	Stevens (31S)
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	77WD	03021378	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	87WD	03021379	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	45WD	03022130	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	57WD	03022131	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	65WD	03022132	Plugged	05	WD	Plugged	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	85WD	03022133	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27S	63SW-WD	03022197	Active	14	WD	Plugged	27	30S	24E	MD	O0495	228	00	Any Area	4th Mya
4	Elk Hills Power, LLC	Elk Hills	-18G	25A	03023952	Idle	05	WD	Active	18	31S	24E	MD	E1100	228	00	Any Area	Tulare
4	Elk Hills Power, LLC	Elk Hills	-18G	35A	03023953	Active	05	WD	Active	18	31S	24E	MD	E1100	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	27WD	03024007	Plugged	05	WD	Plugged	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-25S	47WD	03023793	Active	13	WD	Active	25	30S	24E	MD	O0495	228	00	Any Area	Gas Zone
4	Occidental of Elk Hills, Inc.	Elk Hills	-8G	38A-WD	03024632	Active	05	WD	Active	8	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-26S	84WD-BM	03023794	Active	13	WD	Active	26	30S	24E	MD	O0495	228	00	Any Area	Gas Zone
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	17WD	03025047	Plugged	05	WD	Plugged	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	25WD	03025048	Active	05	WD	Active	31	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	35WD	03025049	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	47WD	03025050	Active	05	WD	Active	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	87WD	03025512	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27S	43WD	03025966	Active	13	WD	Active	27	30S	24E	MD	O0495	228	00	Any Area	Gas Zone

Tulare Wastewater Disposal Wells in the Elk Hills Field

4	Occidental of Elk Hills, Inc.	Elk Hills	[BLANK]	55WD-27R	03026284	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-26S	34WD-G	03026360	Active	13	WD	Active	26	30S	24E	MD	C0495	228	00	Any Area	Gas Zone
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	24WD	03026747	Active	05	WD	Active	13	31S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	44WD	03027214	Active	05	WD	Active	13	31S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	54WD	03027215	Active	05	WD	Active	13	31S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	14WD	03027211	Active	05	WD	Active	13	31S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	44WD	03027986	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	75WD	03027987	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	76WD	03027988	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	86WD	03027989	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	54WD	03027985	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	27WD	03021008	Active	05	WD	Active	18	31S	24E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	45WD	03029340	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	47WD	03029341	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	48WD	03029342	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	56WD	03029343	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	58WD	03029369	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	66D	03029370	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	77WD	03029371	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	78WD	03029372	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare

Tulare Wastewater Disposal Wells in the Elk Hills Field

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Dist	Operator Name	Field Name	Lease	Well#	API	Well Stat	Pool	WellType	PWT Stat	S	T	R	BM	Op Cd	Field	Area	Area Name	Pool Name
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	54XWD	03031791	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	56WD	03031883	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	64XWD	03031884	Active	05	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-18G	73WD	03031877	Active	15	WD	Active	18	31S	24E	MD	O0495	228	00	Any Area	Upper (Undifferentiated)
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	15WD	03033697	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	17WD	03033698	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	35WD	03033699	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	36WD	03033700	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	34WD	03033831	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	474	03033769	Active	05	WD	Cancelled	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	14XWD	03035653	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	84XWD	03035654	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	64WD	03036658	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	65WD	03036659	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	75WD	03036660	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	85WD	03036661	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	86WD	03036662	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	87WD	03036663	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13B	17XWD	03037125	Cancelled	05	WD	Cancelled	13	31S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	24WD	03037149	Cancelled	05	WD	Cancelled	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	44XWD	03037150	Cancelled	05	WD	Cancelled	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	66WD	03039914	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	76WD	03039915	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	77WD	03039916	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	54WD	03041234	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	55WD	03041235	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	56WD	03041236	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	22XWD	03041231	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	12WD	03041230	Active	05	WD	Active	27	30S	23E	MD	O0495	228	00	Any Area	Tulare

Tulare Wastewater Disposal Wells in the Elk Hills Field

4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	52WD	03041407	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	62WD	03041408	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	82WD	03041409	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	11WD	03041834	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-27R	21WD	03041835	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	51WD	03041836	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	61WD	03041837	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	81WD	03041838	Active	05	WD	Active	28	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	53WD	03042354	Active	05	WD	Active	23	30S	22E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	88WD	03042356	Active	05	WD	Active	23	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	58WD	03042798	Active	05	WD	Active	21	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	68WD	03042799	Active	05	WD	Active	21	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	88WD	03042800	Active	05	WD	Active	21	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	18WD	03042801	Active	05	WD	Active	22	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	28WD	03042802	Active	05	WD	Active	22	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	27R	24WD	03043855	Active	05	WD	Active	27	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	56WD	03044228	Active	05	WD	Active	21	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	16WD	03045138	Active	05	WD	Active	22	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	26WD	03045139	Active	05	WD	Active	22	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	27WD	03045140	Active	05	WD	Active	22	30S	23E	MD	C0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	66WD	03045141	Active	05	WD	Active	21	30S	23E	MD	C0495	228	00	Any Area	Tulare

Tulare Wastewater Disposal Wells in the Elk Hills Field

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Dist	Operator Name	Field Name	Lease	Well#	API	Well Stat	Pool	WellType	PWT Stat	S	T	R	BM	Op Cd	Field	Area	Area Name	Pool Name
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	86WD	03045142	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	22WD	03045287	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	31WD	03045288	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	32WD	03045289	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	42WD	03045290	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	11WD	03045355	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	12WD	03045356	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	21WD	03045357	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-28R	41WD	03045327	Active	05	WD	Active	28	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	37WD	03045661	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	38WD	03045662	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	45WD	03045663	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	46WD	03045664	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	47WD	03045665	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	48WD	03045666	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	55WD	03045667	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	65WD	03045668	Cancelled	05	WD	Cancelled	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	75WD	03045669	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	85WD	03045670	Cancelled	05	WD	Cancelled	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	15WD	03045671	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	16WD	03045672	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	17WD	03045673	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	18WD	03045674	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	25WD	03045675	Cancelled	05	WD	Cancelled	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	26WD	03045676	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	27WD	03045677	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	28WD	03045678	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	35WD	03045679	Cancelled	05	WD	Cancelled	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	36WD	03045680	Cancelled	05	WD	Cancelled	21	30S	23E	MD	O0495	228	00	Any Area	Tulare

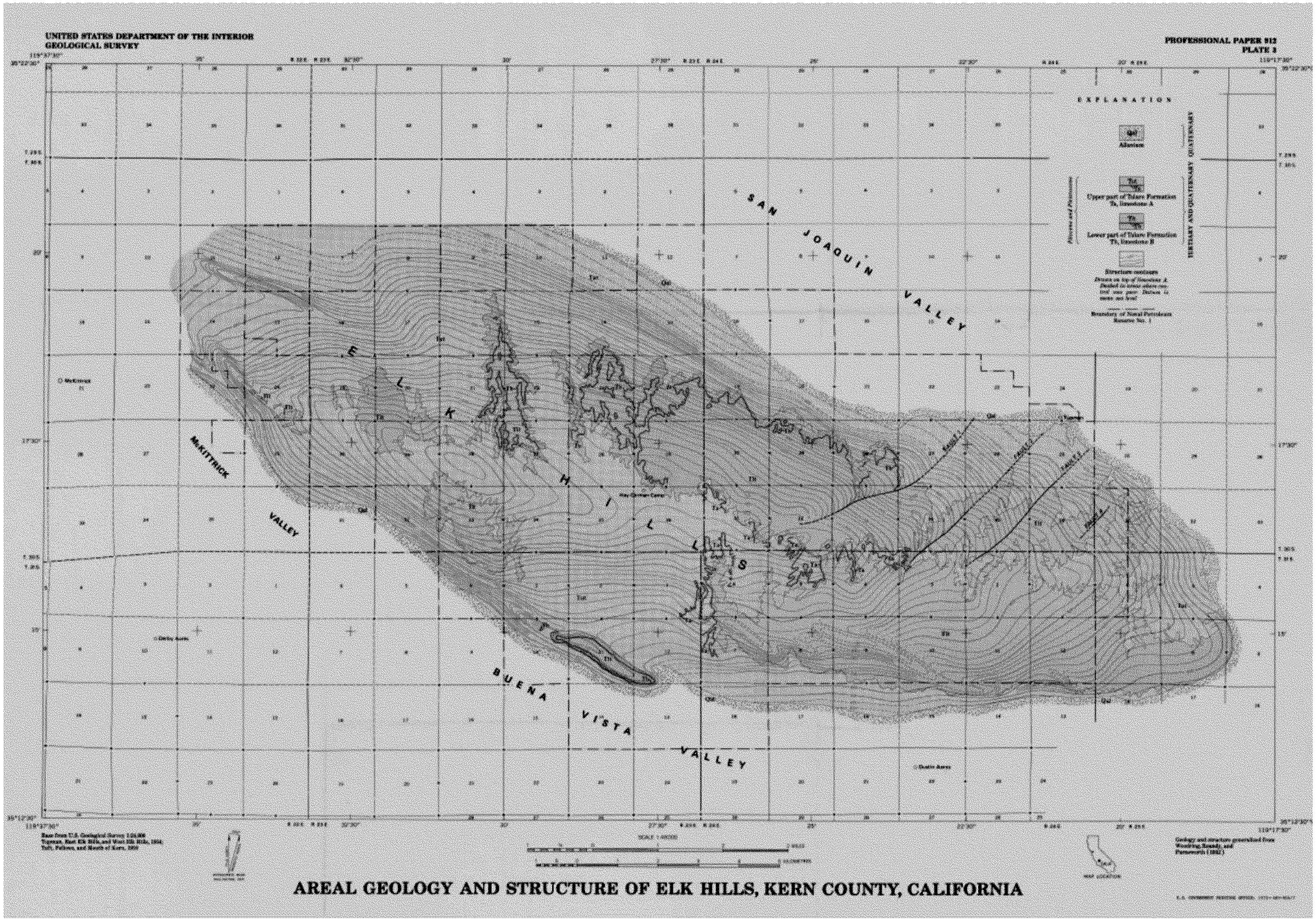
Tulare Wastewater Disposal Wells in the Elk Hills Field

4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	15WD	03045732	Active	05	WD	Active	22	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	25WD	03045733	New	05	WD	New	22	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	57WD	03044756	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	67WD	03044757	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	78WD	03042355	Active	05	WD	Active	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	87WD	03044758	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-22R	17WD	03044755	Active	05	WD	Active	22	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	52WD	03053135	New	05	WD	New	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	74WD	03053136	New	05	WD	New	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-23Z	63WD	03053138	New	05	WD	New	23	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-25Z	54WD	03053063	New	05	WD	New	25	30S	22E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	85WDX	03053849	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	25WDX	03053845	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	35WDX	03053846	Active	05	WD	Active	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	36WDX	03053847	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-21R	65WDX	03053848	New	05	WD	New	21	30S	23E	MD	O0495	228	00	Any Area	Tulare
4	Vintage Prod California LLC	Elk Hills	-25Z	63WD	03054570	New	05	WD	New	25	30S	22E	MD	V1370	228	00	Any Area	Tulare
4	Vintage Prod California LLC	Elk Hills	-25Z	64WD	03054571	New	05	WD	New	25	30S	22E	MD	V1370	228	00	Any Area	Tulare
4	Vintage Prod California LLC	Elk Hills	-25Z	74WD	03054572	New	05	WD	New	25	30S	22E	MD	V1370	228	00	Any Area	Tulare
4	Vintage Prod California LLC	Elk Hills	-25Z	84WD	03054573	New	05	WD	New	25	30S	22E	MD	V1370	228	00	Any Area	Tulare
4	Occidental of Elk Hills, Inc.	Elk Hills	-13Z	328	02968879	Active	22	WF	Plugged	13	30S	22E	MD	O0495	228	00	Any Area	Stevens (29R)

Tulare Wastewater Disposal Wells in the Elk Hills Field

Exhibit 15

Geologic Map



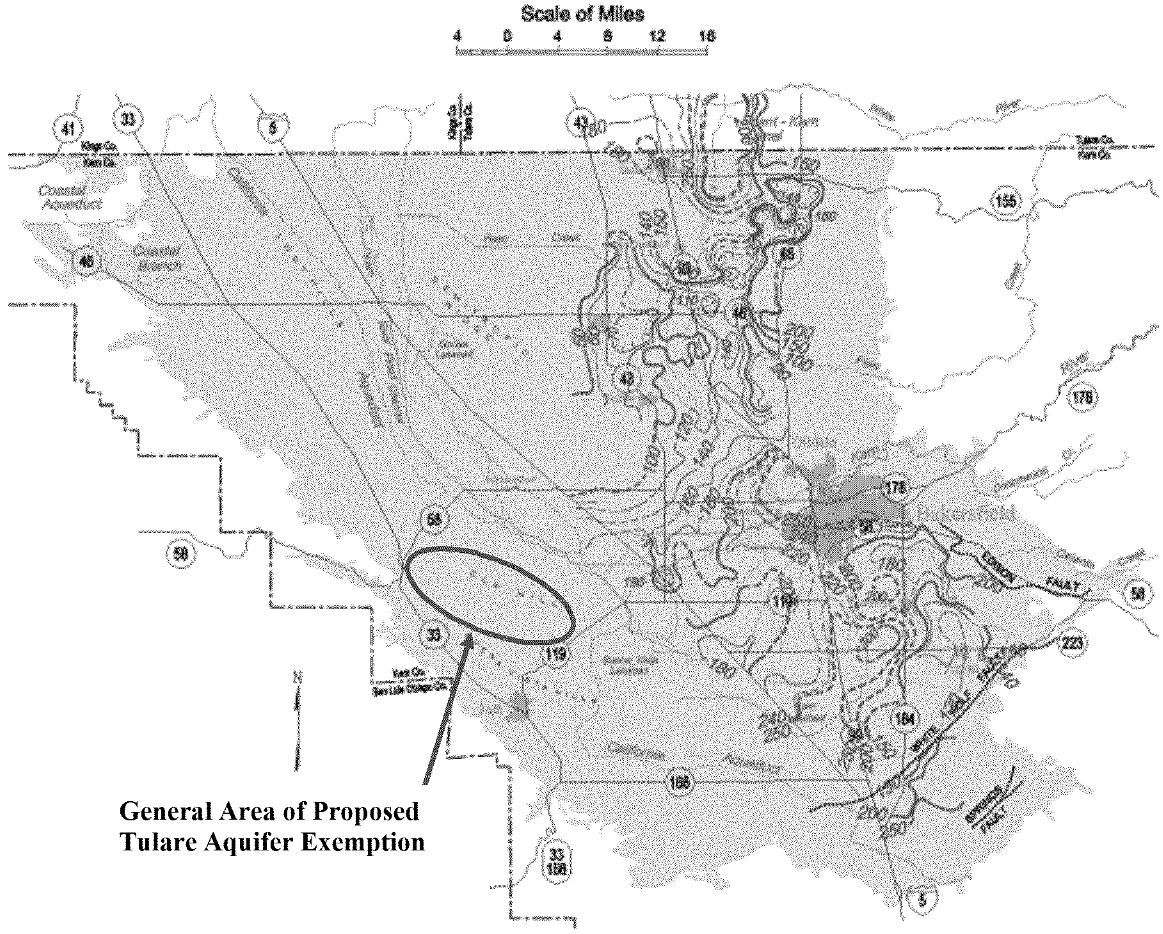
(Source: Maher et al., 1975)

Exhibit 16

Regional Groundwater Elevation Map of the Unconfined Aquifer

Kern Groundwater Basin

Spring 2005, Lines of Equal Elevation of Water in Wells, Unconfined Aquifer

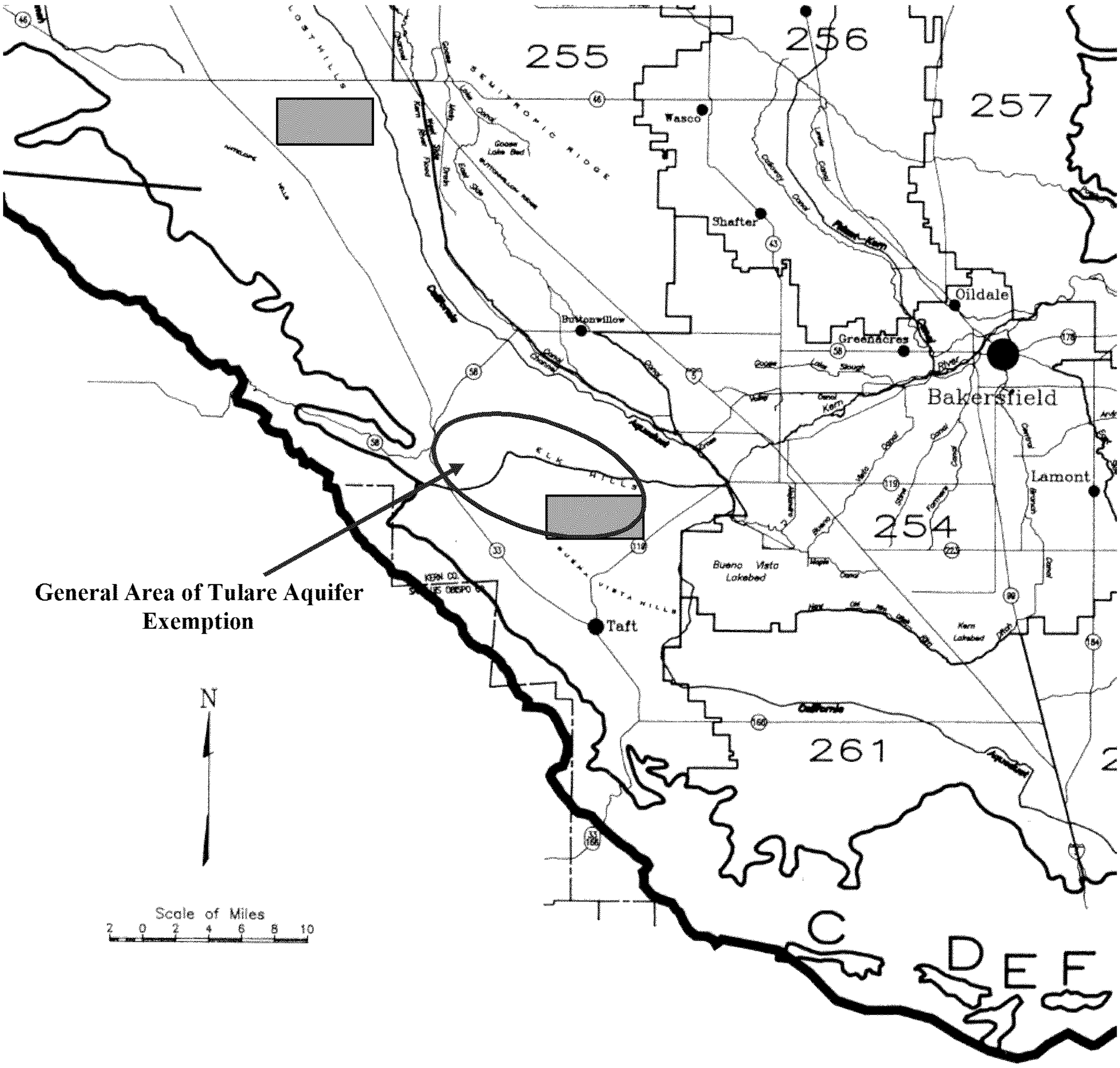


Contours are dashed where inferred. Contour interval is 10, 20 and 50 feet.

Groundwater Elevation Map of Unconfined Aquifer (Department of Water Resources, 2005)
No unconfined aquifers shown in Tulare aquifer exemption area.

Exhibit 17

Map of Designated Analysis Units in the Kern County Subbasin



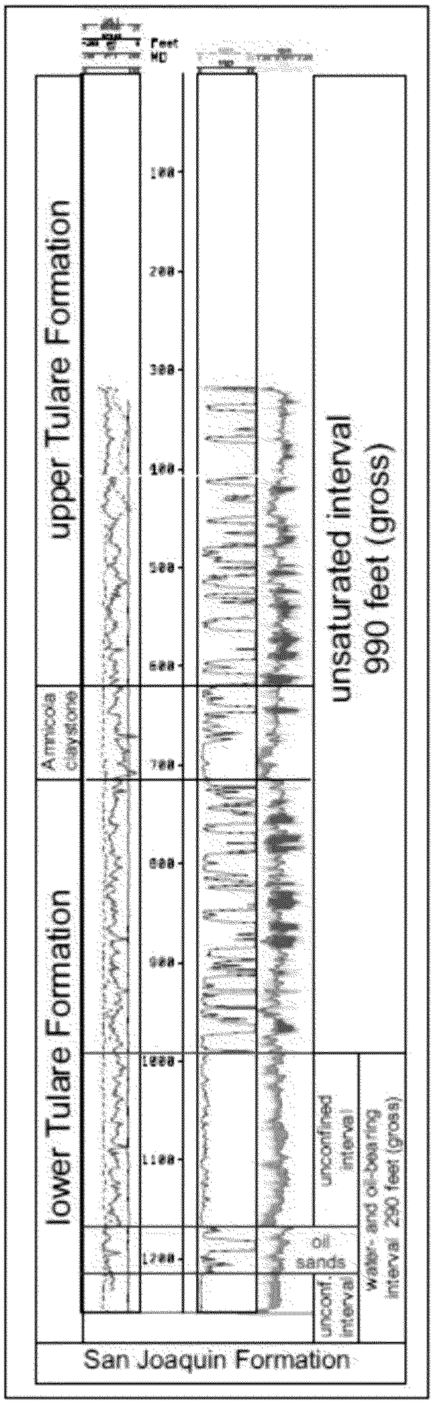
Designated Analysis Units within the Area of Review, Kern County Subbasin

(California Regional Water Quality Control Board, 2004)

Exhibit 18

Type Log[22]

[22] All geologic exhibits in this document were prepared by Mr. Stephen A Reid of OEHI, California -licensed Professional Geologist No. 3876.



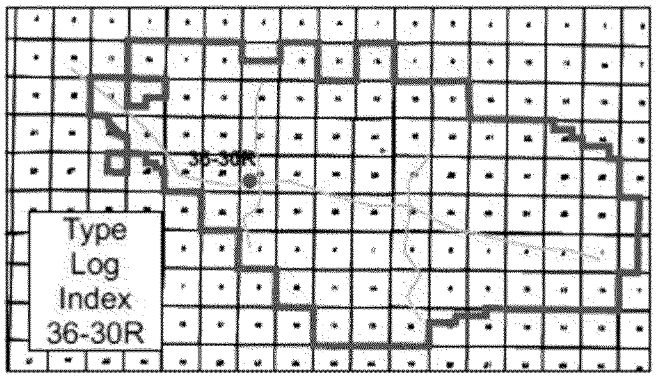
Type Log
Tulare Formation
(Pleistocene)
Western Elk Hills Field
Well 36-30R

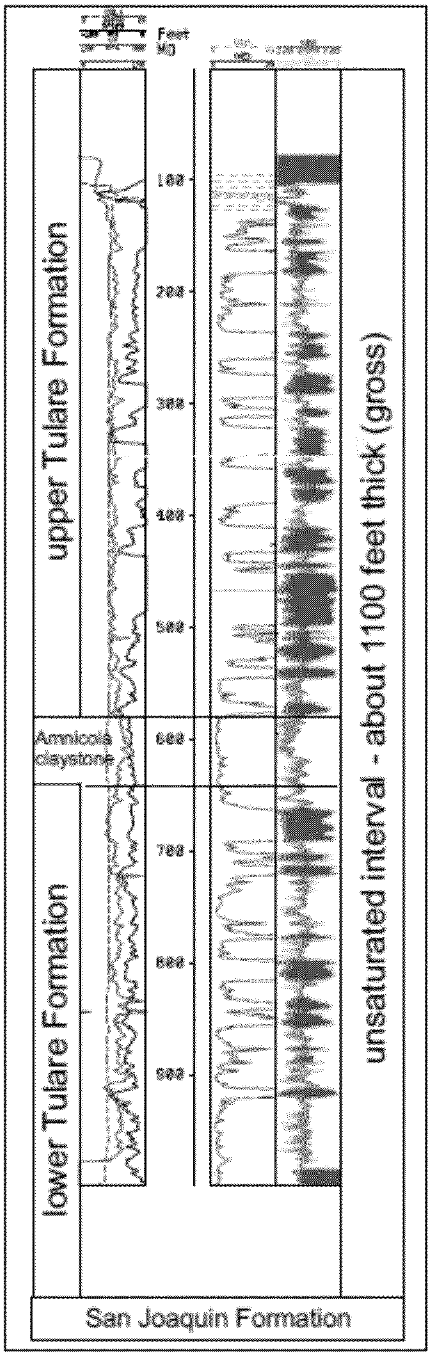
Well Information:

elevation 1302.0 feet KB
completed May 16, 1984
operator: Occidental of Elk Hills, Inc.
total depth: 1255 feet (md)
completed interval: Tulare Formation
status: plugged and abandoned

Hydrocarbon and Water Character:

hydrocarbon occurrences: unknown
oil sands encountered in core from 1167 to 1214 feet (md). Well produced only 71 barrels oil during a short test in 1984.
Water characteristics: unknown

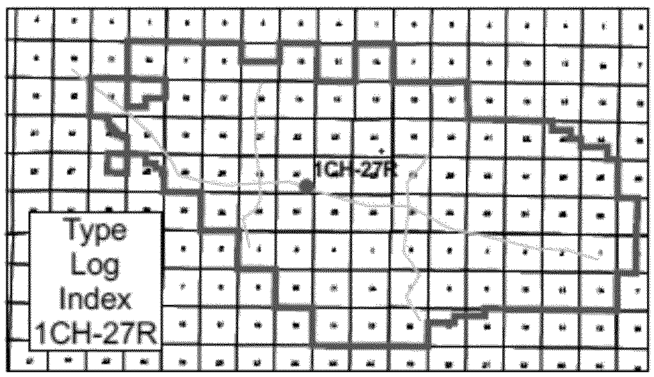


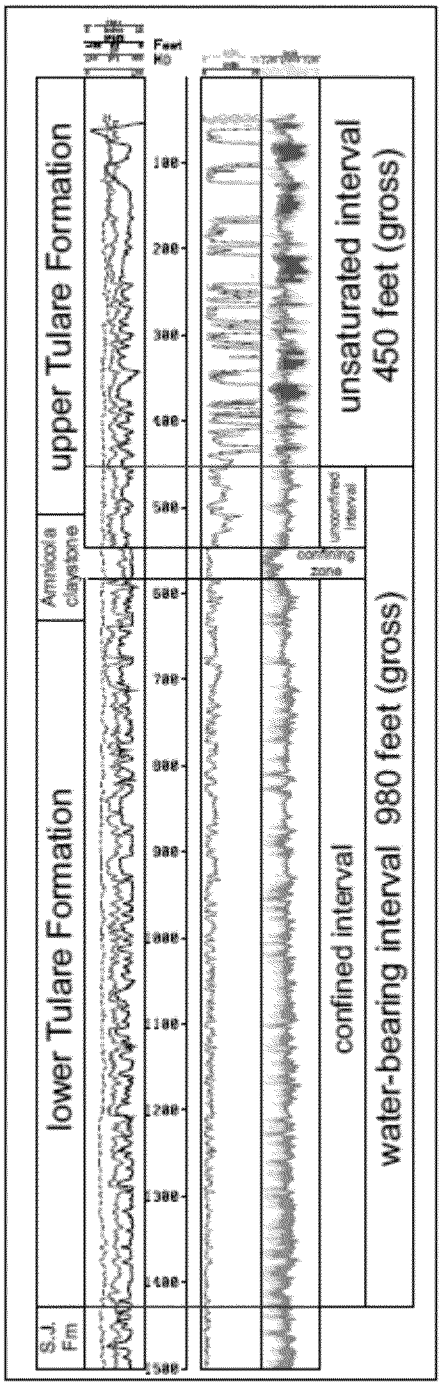


Type Log
Tulare Formation
(Pleistocene)
Central Elk Hills Field
Well 1CH-27R

Well Information:
elevation 1400.0 feet KB
completed May 8, 1990
operator: Bechtel Petroleum Operations, Inc.
(now Occidental of Elk Hills, Inc.)
total depth: 1000 feet (md)
drilled as a core well to test for shallow contamination
status: plugged and abandoned

Hydrocarbon and Water Character:
hydrocarbon occurrences: unknown
water characteristics: density-neutron logs show a "cross over" effect (red on log) and indicates unsaturated conditions. Offset wells confirm unsaturated conditions to the base of the Tulare in Section 27R.





Type Log
Tulare Formation
(Pleistocene)
South East Elk Hills Field
Well 38E-9G

<u>Well Information:</u>
elevation 690.4 feet KB
completed Nov. 22,2001
operator: Occidental of Elk Hills, Inc.
total depth: 4123 feet (md)
completed interval: Etchegoin/San Joaquin
status: inactive producer

<u>Hydrocarbon and Water Character:</u>
hydrocarbon occurrences: unknown
water characteristics: test in nearby well 48-9G yielded 7,168 ppm TDS from 595 to 935 feet (md), and 12,647 ppm TDS from 1040 to 1275 feet (md)

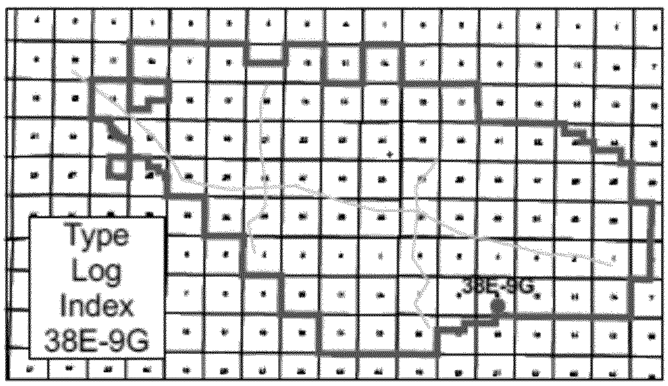


Exhibit 19

Structure Contour Map of the Base of the Tulare Formation

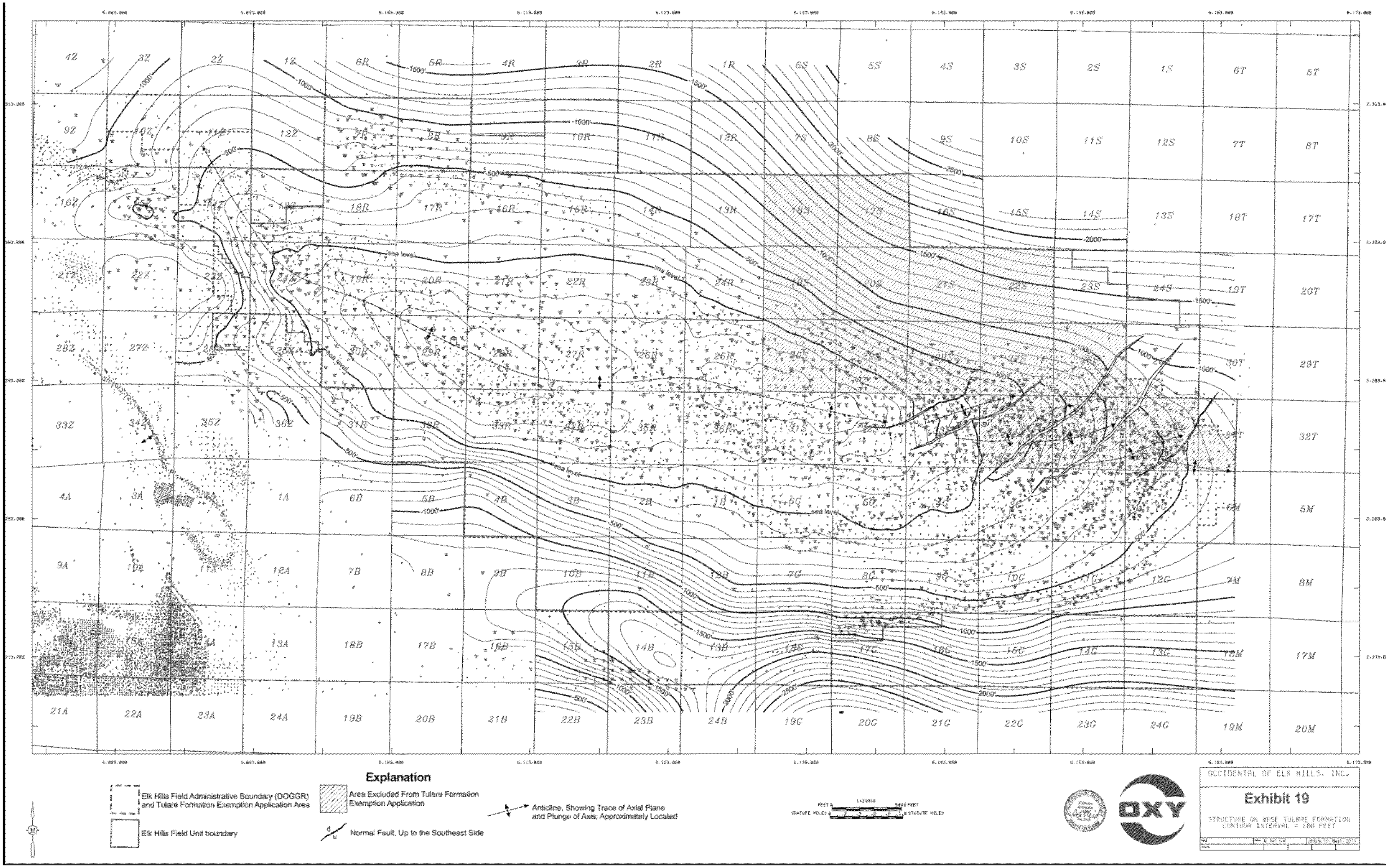
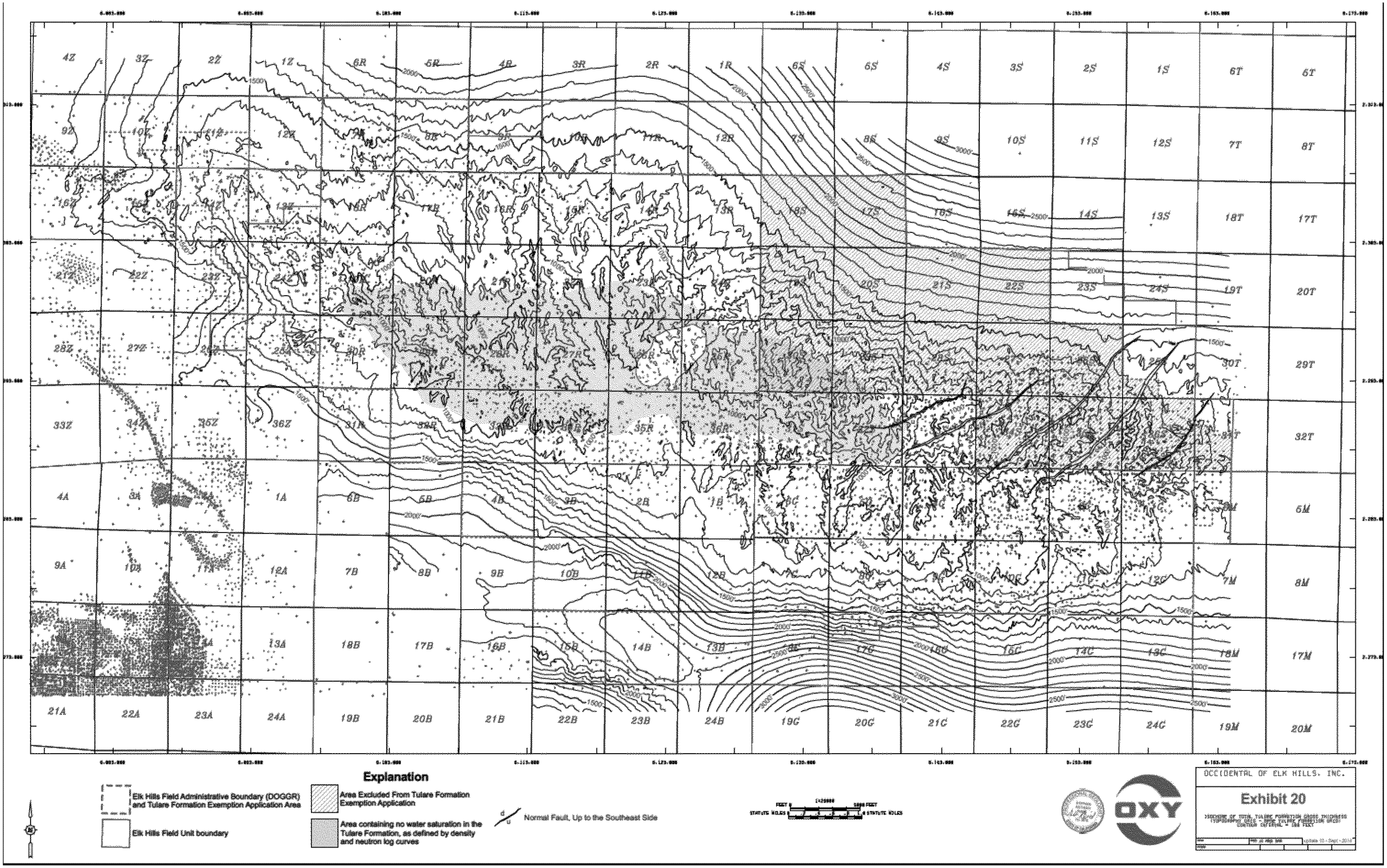

Explanation
Elk Hills Field Administrative Boundary (DOGGR) and Tulare Formation Exemption Application Area
Elk Hills Field Unit boundary
Area Excluded From Tulare Formation Exemption Application
Normal Fault, Up to the Southeast Side
Anticline, Showing Trace of Axial Plane and Plunge of Axis; Approximately Located
OXY
OCCIDENTAL OF ELK HILLS, INC.
Exhibit 19
STRUCTURE ON BASE TULARE FORMATION
CONTOUR INTERVAL = 100 FEET
sea level
-500'
-1000'
-1500'
-2000'
-2500'

Exhibit 20

Isochore Map of the Tulare Formation Gross Thickness



Explanation
Elk Hills Field Administrative Boundary (DOGGR) and Tulare Formation Exemption Application Area
Elk Hills Field Unit boundary
Area Excluded From Tulare Formation Exemption Application
Area containing no water saturation in the Tulare Formation, as defined by density and neutron log curves
Normal Fault, Up to the Southeast Side
OCCIDENTAL OF ELK HILLS, INC.
Exhibit 20
OXY

Exhibit 21

Structural Cross-Sections

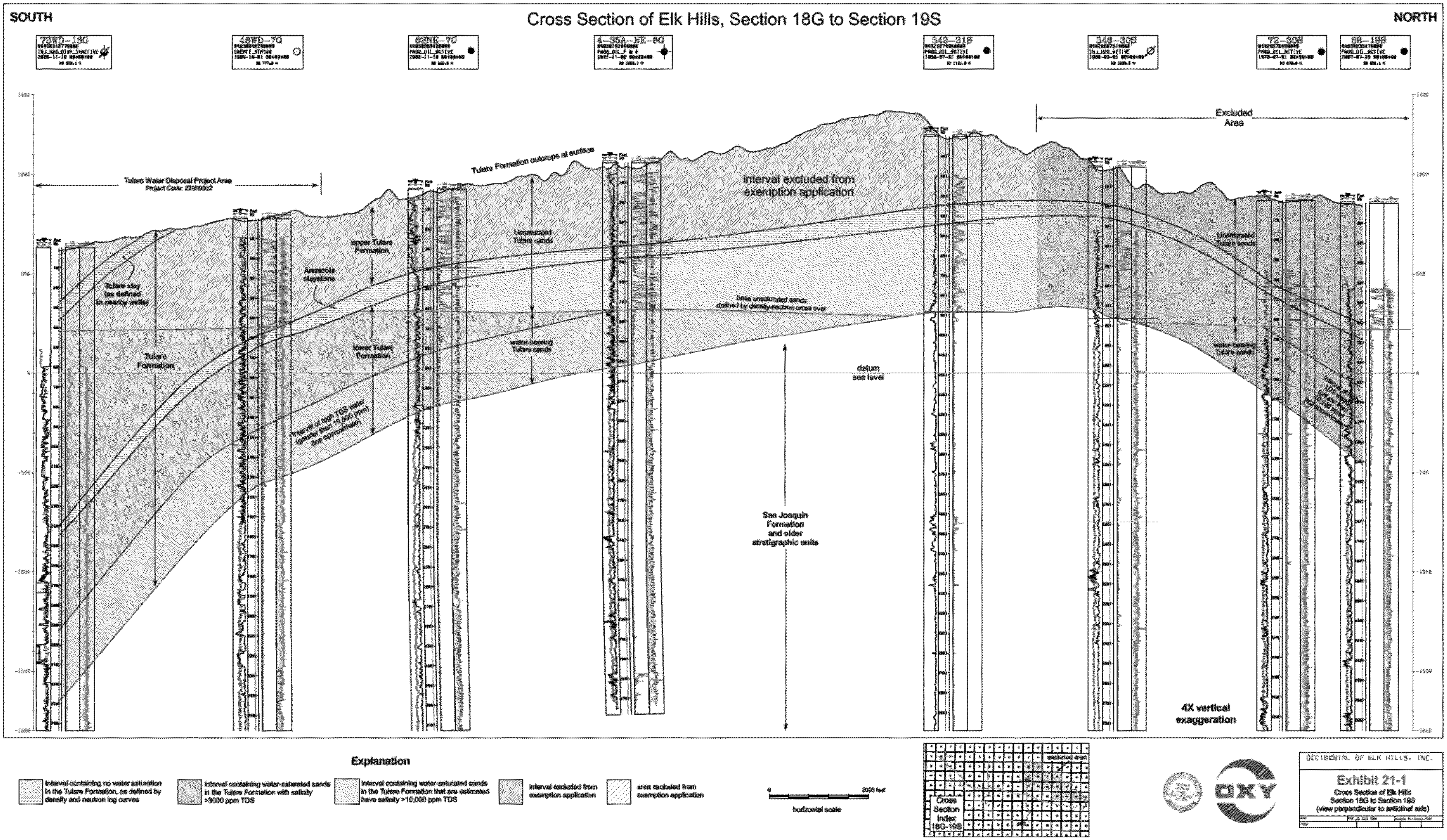


Exhibit 21-1: North-south cross-section along dip in the central area of the Elk Hills field

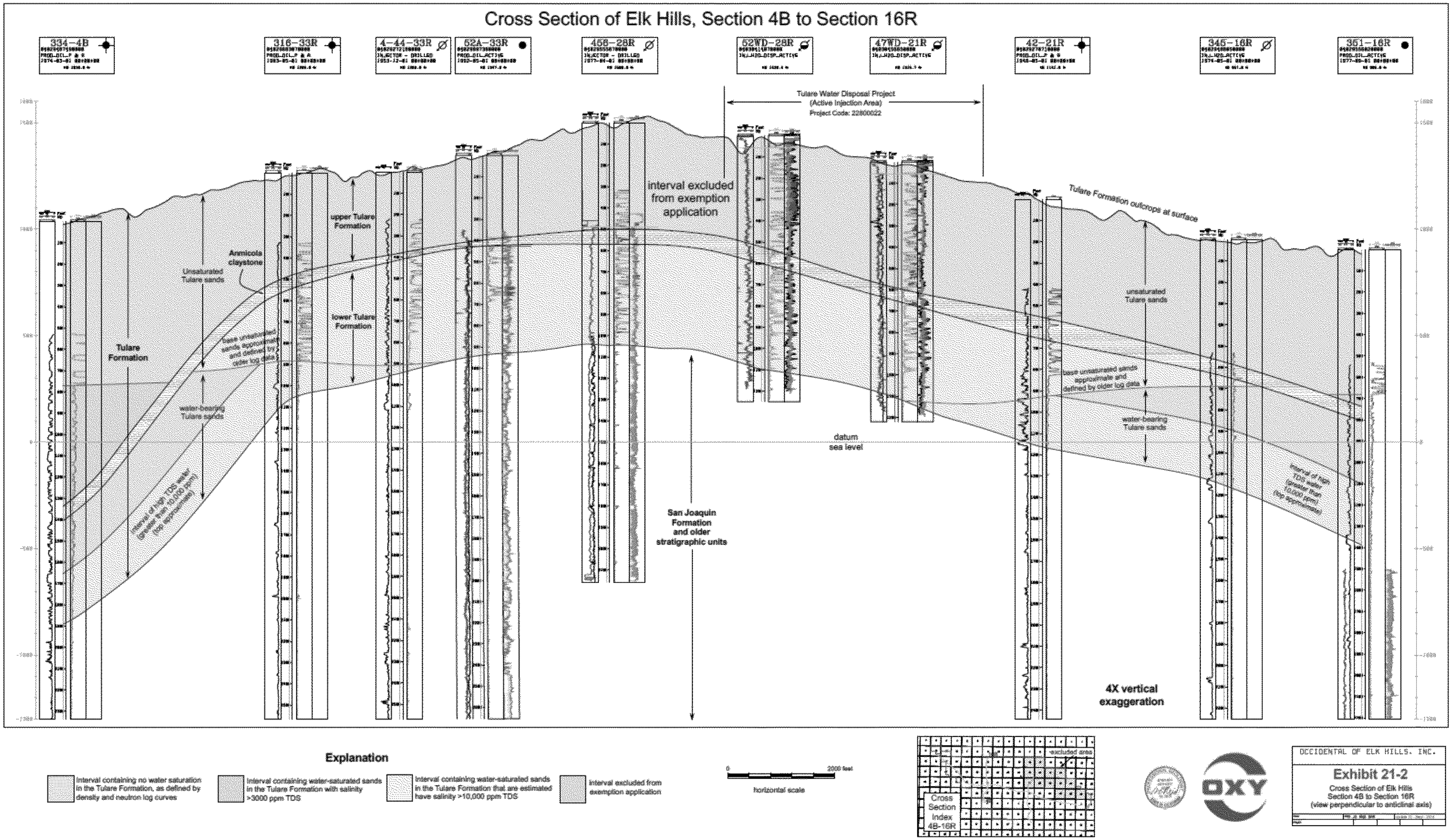


Exhibit 21-2: North-south cross-section along dip in the west-central area of the Elk Hills field

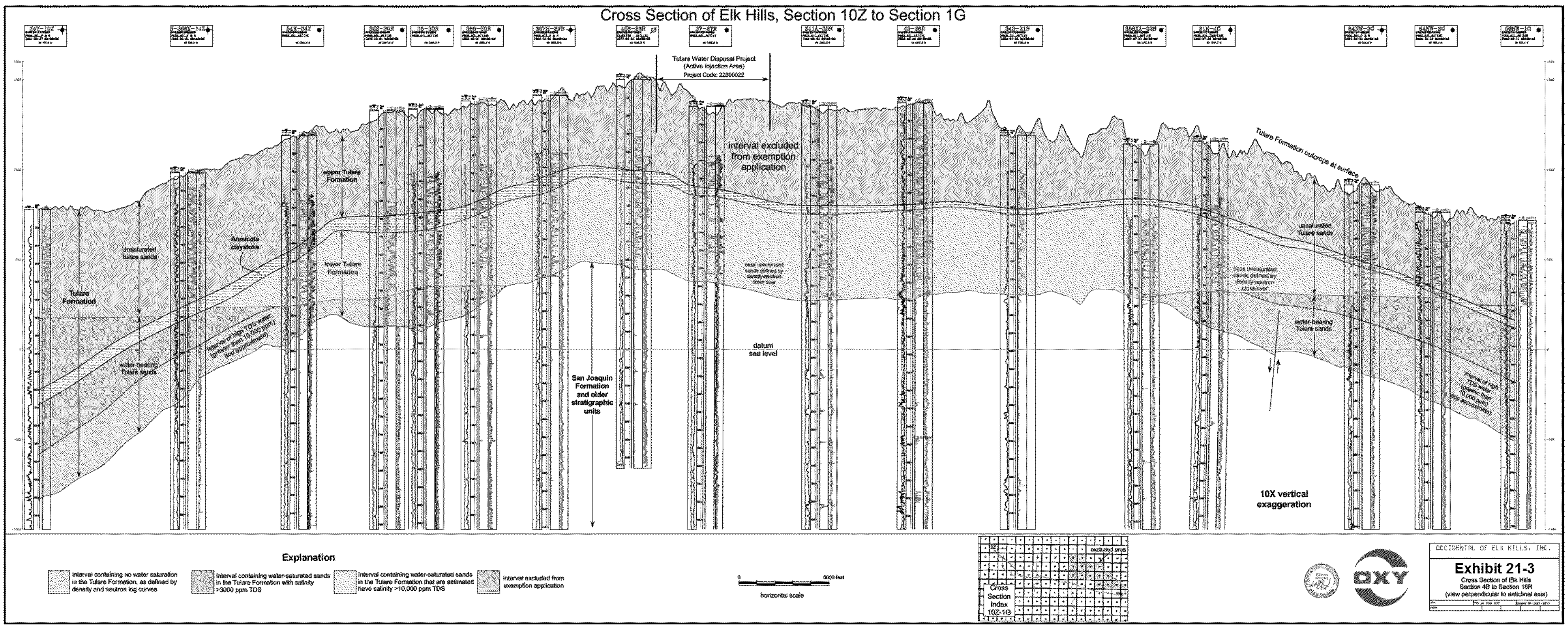
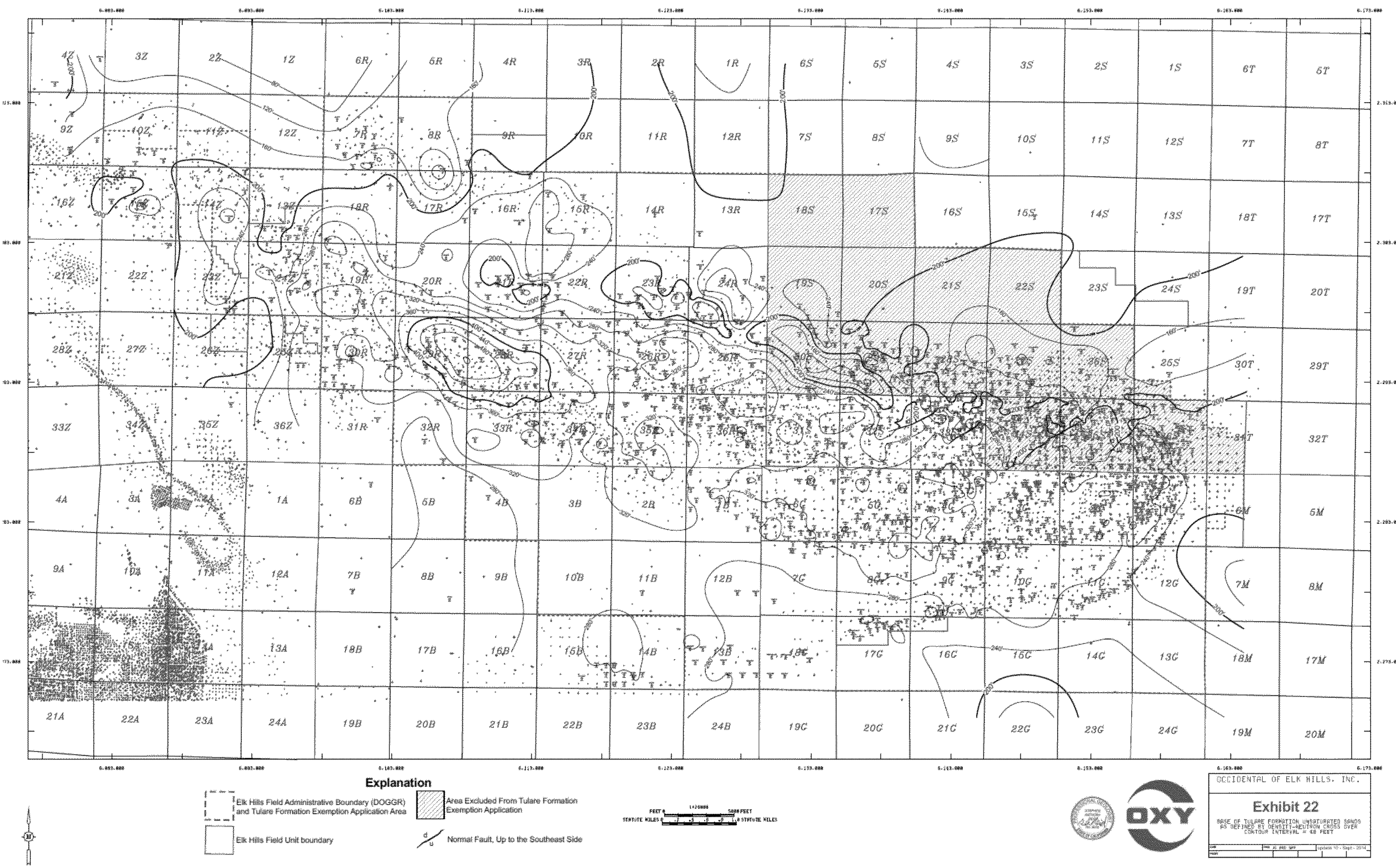


Exhibit 21-3: Northwest-southeast cross-section along strike through the central area of the Elk Hills field

Exhibit 22

Structure Contour Map of the Base of the Tulare Unsaturated Zone



ED_001000_00029908-00155

Exhibit 23

Isochore Map of the Unsaturated Tulare Zone

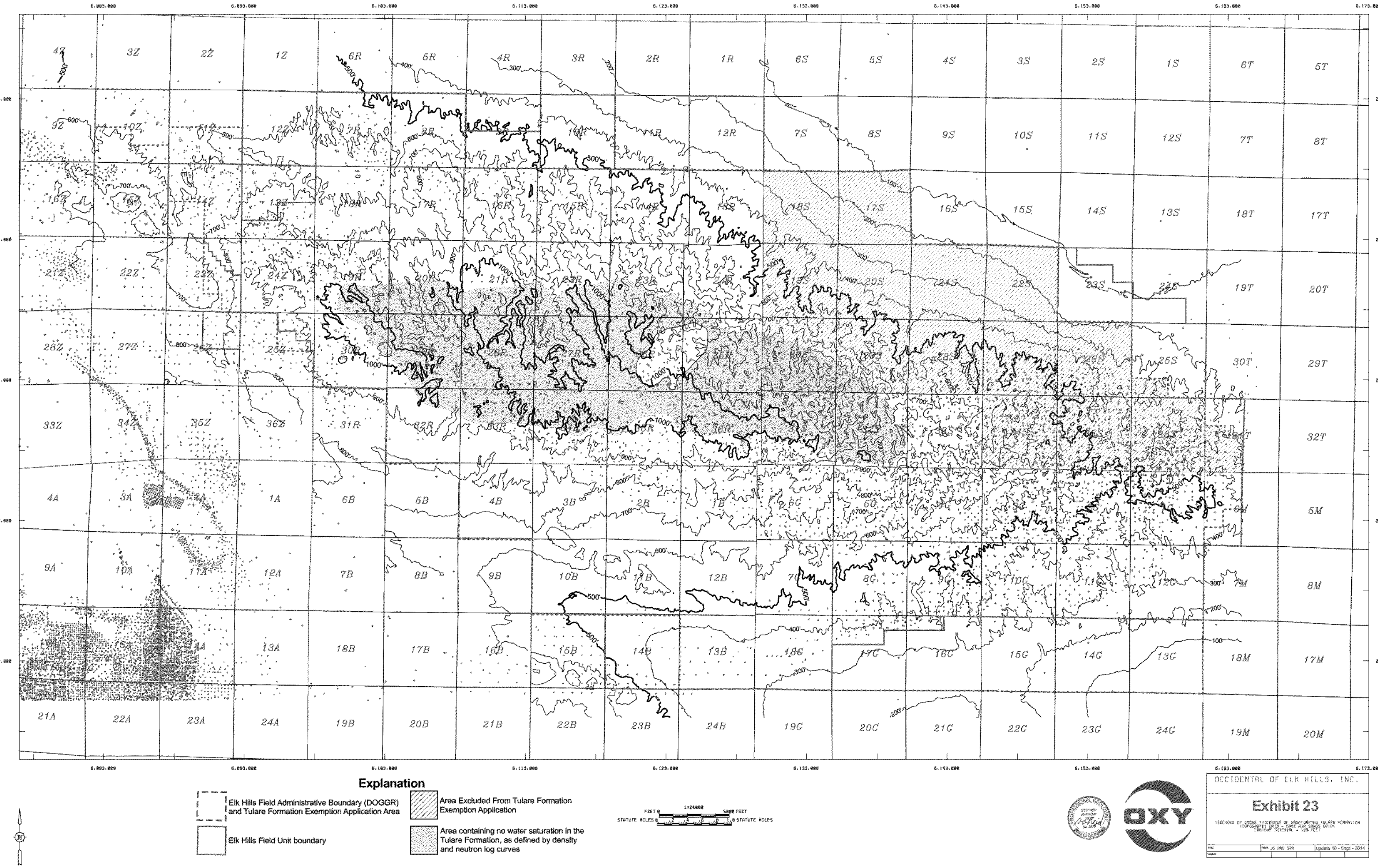
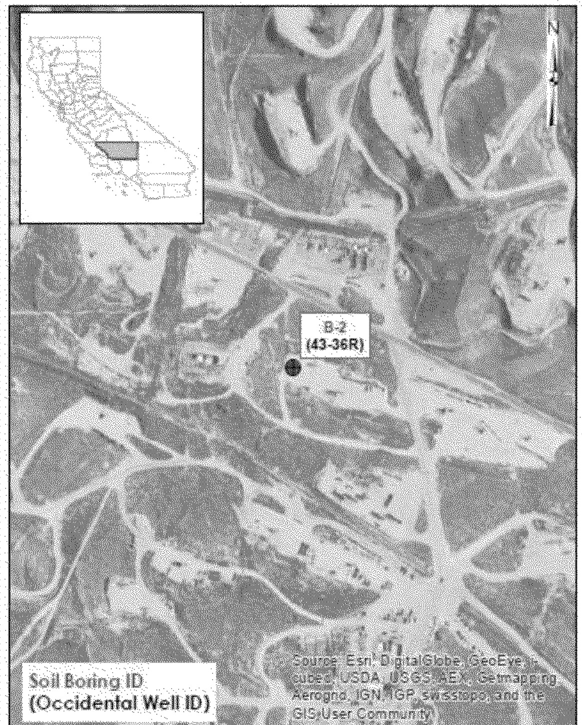
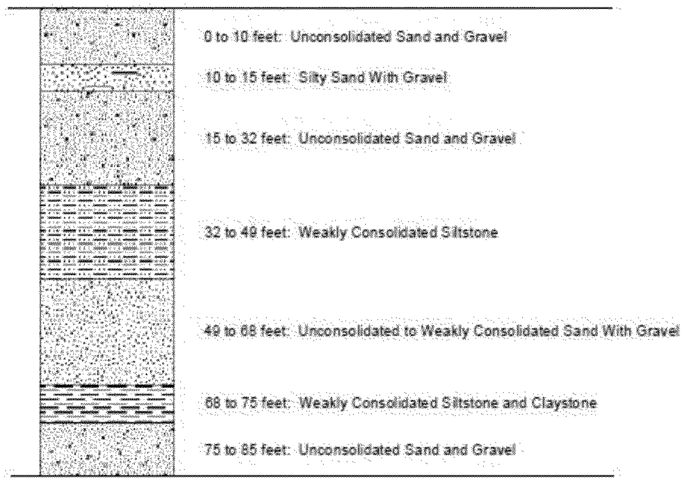

Explanation
Elk Hills Field Administrative Boundary (DOGGR) and Tulare Formation Exemption Application Area
Elk Hills Field Unit boundary
Area Excluded From Tulare Formation Exemption Application
Area containing no water saturation in the Tulare Formation, as defined by density and neutron log curves
1:24000
FEET 0 5000 FEET
STATUTE MILES 0 .2 .4 .6 .8 1.0 STATUTE MILES
OCCIDENTAL OF ELK HILLS, INC.
Exhibit 23
update 10 - Sept - 2014

Exhibit 24

Stantec Borehole 43-36R



*The location shown is for the soil boring located approximately 36-feet west-southwest of the associated Occidental Well (as labeled).



Stantec 290 Conejo Ridge Ave Thousand Oaks, CA 91361 Phone 805.230.1266 Fax 805.230.1277 www.stantec.com	For: OXY Occidental of Elk Hills, Inc. 28590 Highway 119 Tupman, California 93276		Soil Boring B-2 Summary Lithologic Log		Figure: 1
	Job Number: 185850241	Drawn By: Michael Bartosek	Checked By: StephAnnie Roberts	Approved By: Gareth Roberts	Date: 04/16/2014

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

ELK HILLS OIL FIELD SHALLOW GROUNDWATER INVESTIGATION

Appendix B PHOTOGRAPH LOGS
April 17, 2014

Photo 1:

Samples collected from boring B-2 at 0 through 50 feet bgs (including 5 foot sample from hand auger)

Photo 2:

Samples collected from boring B-2 at 50 through 85.5 feet bgs

Stantec

B.1

ELK HILLS OIL FIELD SHALLOW GROUNDWATER INVESTIGATION

Appendix B PHOTOGRAPH LOGS
April 17, 2014

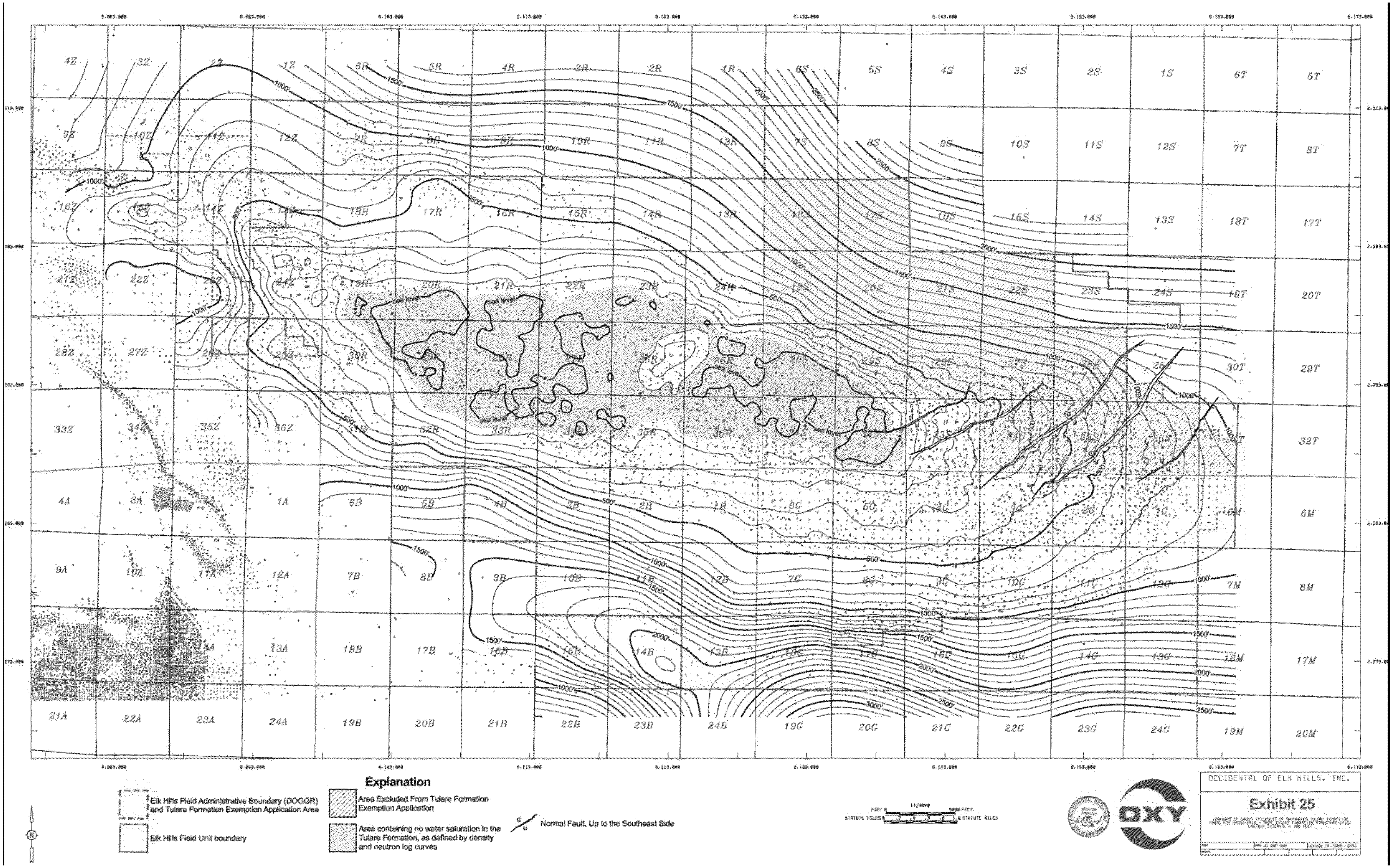
Photo 3:

Tulare Formation Outcrop near B-2 borehole location

Stantec Borehole B-2 (43-36R)

Exhibit 25

Isochore Map of the Saturated Tulare Zone



ED_001000_00029908-00161

Exhibit 26

Summary of Water Well Data within the Area of Review

Quad Knopf

June 18, 2014

Mr. Richard Garcia
Occidental Petroleum
28590 Highway 119
Tupman, CA 93276

Subject: Research for Occidental Petroleum on Potential Water Wells Located in the Following Sections: 17R, 13G, 14G, 18G,19S, 20S, 22S, 23S and 32S.

Dear Mr. Garcia:

Quad Knopf, Inc. is pleased to provide you with the results of our Water Well Research for the above referenced properties in support of Occidental Petroleum's DOGGR aquifer exemption application. We declare that we have performed the requested inquiry to the best of our professional knowledge and belief. Our services were provided in accordance with an email proposal dated May 16, 2014 with an email notice to proceed on May 20, 2014 from Brian Fowler.

As requested, Quad Knopf was to verify the presence or lack thereof, of water wells (irrigation or domestic) that fall within the bounds of the Elk Hills oil field, specifically for sections 17R, 13G, 14G, 18G, 19S, 20S, 22S, 23S and 32S.

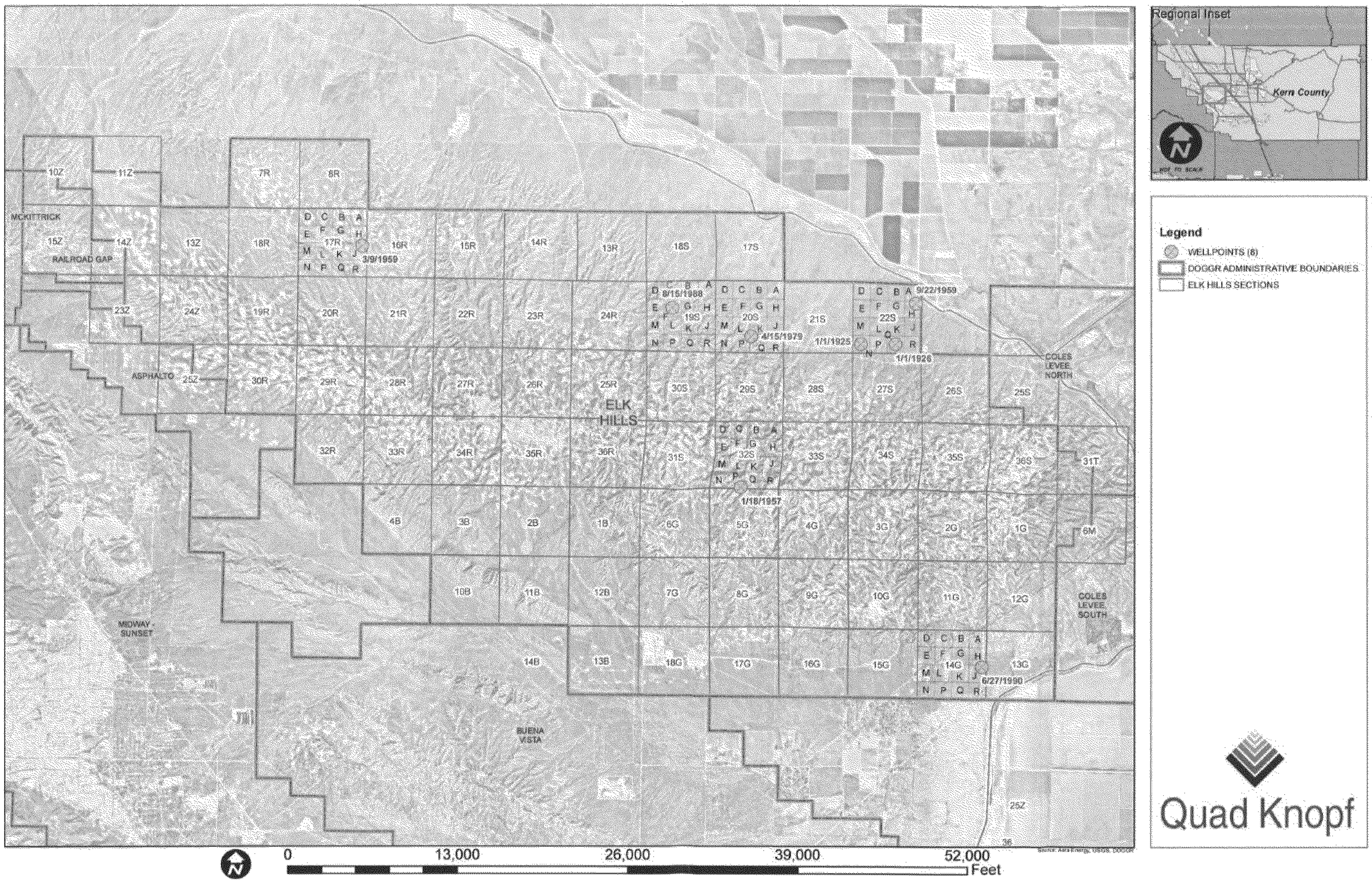
In our records review and site reconnaissance visit for Occidental Petroleum Elk Hills research project, it was determined that a number of water wells (industrial, irrigation and domestic) were listed (current and historical) that fall within the bounds of the Elk Hills oil field (specifically in the sections requested or directly adjacent). Of these potential water wells two (2) were determined to be cathodic protection, one (1) an abandoned house with no evidence of a well, four (4) projected well sites had no evidence of a well within a 500+/- foot radius and one (1) well drilled in 1990 by Texaco Oil for industrial purposes that could not be located in Section 14G near the Dustin Acres residential development off of golf course road east of Highway 119. West Kern Water District provides all domestic water to the Dustin Acres residential area. See attached photoplates for additional detail. Therefore, based upon our research and reconnaissance it was determined that no domestic water wells are located within the Elk Hills oil field boundary (see attached map).

If you have any questions regarding this report, or need further information, please contact Kristie Achee or Heather Ellison at (661) 616-2600.

Quad Knopf, Inc

Kristie Achee
Survey Department Manager

5080 California Avenue, Suite 220, Bakersfield, CA 93309 • Tel (661) 616-2600 • Fax (661) 616-5970

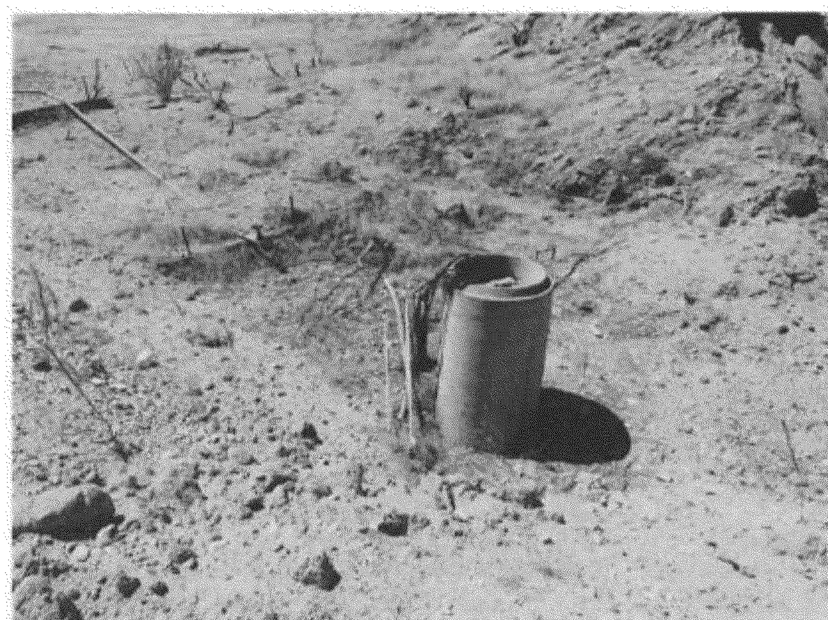


Map of well locations verified by Quad Knopf, shown in red.

Site	Location - General	Defined Location	Date	Well No.	Depth	Oil or Water (Domestic/Irrigation)	Water Depth	Owner	Results of Site Reconnaissance
Sections Requested by Oxy: 17R, 13G, 14G, 18G,19S, 20S, 22S, 23S and 32S									
2	Section 17R (30S/23E)	65 Ft E to sec line, 2400 ft S to sec line from well	3/9/1959	17J	378	Irrigation	36	Orlando Torigiani	Anode well
3	Section 19S (30S/24E)	Tract 2139 APN 180-050-39-00-2	8/15/1988	19F 283566	305	Water (Domestic)	30	Cesar A. Vasquez	Nothing found within 500 ft radius
4	Section 20S (30S/24E)	NW corner of SW quarter of southeast quarter	4/15/1979	20Q 22135	780	Water (Industrial)	433	Naval Petroleum Reserve #1	Anode well/ not in service
7	Section 22S (30S/24E)	400 ft east to Section line from well, 1450 ft north	9/22/1959	22H 34225	348	water Irrigation	80	O.M Roberta	Nothing found within 500 ft radius
5	Section 22S (30S/24E)	Unknown*	1925	22N	1375	Unknown		Unable to read	Nothing found within 500 ft radius
6	Section 22S (30S/24E)	Unknown*	1926	22Q	3356	Uknown		Unable to read	No visible evidence of water well. House and other structures adjacent are abandoned.
8	Section 32S ((30S/24E)	100 ft south oto section line from well, 2400 ft west	1/18/1957	44432	346	domestic water	32.5	Opal Culp	Nothing found within 500 ft radius
9	Section 14G (31S/24E)	3/4 mi east of hwy 119 on golf course rd	6/27/1990	14H 278652	312	industrial water	N/A	Texaco USA	No evidence of well located within 500 ft radius. Location of well listed near the Dustin Acres residential development.

Note: Domestic water wells did not require any notification or permitting with the County prior to 1980.
* wells included on list due to extremely old dates and likelihood of the wells abandoned without record.

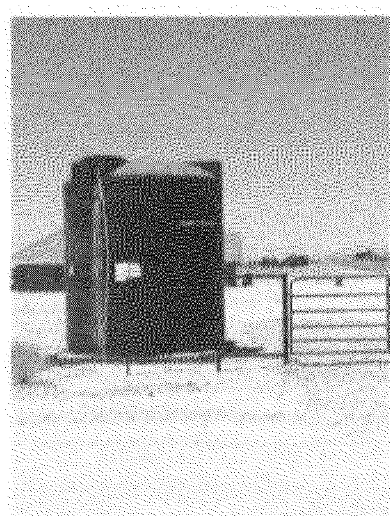
Site 2 was an anode well.



Site 4- anode well - Not in service

Quad Knopf	PHOTOPLATE	1

Site 6 - No visible evidence of a water well. Structures adjacent to the well are abandoned.



Site 9 - Water tank. No well visible, but the tank appears to have a fill line running up the side. This address, 11711 Hatch St, is receiving its domestic water from West Kern Water District.

Quad Knopf	PHOTOPLATE	2

Exhibit 27

Tulare Groundwater Analyses

TDS DATA FOR INDIVIDUAL SOUTH FLANK TULARE WELLS: 1979 TO 1993

GROUNDWATER QUALITY DATA – TULARE WATER SOURCE WELLS			
Well	**Average TDS Concentration (mg/l)**	**Year**	**Remarks**
43WS-13B	4,485	1993	Idle water source well
284WS-13B	4,545	1993	Abandoned water source well
282WS-14B	5,820	1993	Abandoned water source well
45WS-18G	6,142	1993	Abandoned water source well
86WS-18G	5,665	1993	Idle water source well
48-9G	7,168	1978	Abandoned water source well
48-9G	11,788	1978	Abandoned water source well
57WS-9G	6,570	1978	Abandoned water source well
57WS-9G	11,752	1978	Abandoned water source well
61WS-8R*	7,009	1987	Abandoned water source well
(Source: Phillips, 1992; NPR-1 Ground Water Protection Management Program, April 1994)			

*An updated groundwater analysis from 61WS-8R, dated May 17, 1988, had a TDS concentration of 8,720 mg/l (OEHI UO-NPR#1 Laboratory Services, Geochemical Water Analysis).

NOTE: Analyses in the lower Tulare Formation which have TDS concentrations greater than 190,000 mg/l are highlighted in yellow. All other groundwater analyses are from the upper Tulare interval.

Table 5. TULARE FORMATION - SOUTH FLANK MEAN WATER ANALYSIS DATA

GENERAL MINERALS	mg/l	METALS	mg/l
Calcium, Ca	375.00	Antimony, Sb	<0.20
Magnesium, Mg	102.00	Arsenic, As	0.0047+
Sodium, Na	1217.00	Barium, Ba	<0.10
Potassium, K	8.20	Beryllium, Be	<0.01
Iron, Fe	0.20	Cadmium, Cd	<0.01
Hydroxide, OH	0.00	Chromium, Cr	<0.05
Carbonate, CO_3	0.00	Cobalt, Co	<0.10
Bicarbonate, HCO_3	180.00	Copper, Cu	<0.04+
Chloride, Cl	1625.00	Lead, Pb	0.0208+
Sulfate, SO_4	1435.00	Mercury, Hg	<0.002
Boron, B	6.16	Molybdenum, Mo	0.103+
TDS (Grav.)	5025.00	Nickel, Ni	0.0559+
		Selenium, Se	<0.005
pH	7.60	Silver, Ag	<0.02
Electrical Conductivity (mohm-meters)	7330.00	Thallium, Th	<0.20
Specific Gravity (g/cm^3)	1.004	Vanadium, V	<0.10
Resistivity (Ohm-meter)	1.40	Zinc, Zn	0.0589+

NOTE: Mean values based on 1993 data from four south flank water source wells.
+ Cohen's Method Used.

Average Concentrations in South Flank Tulare Groundwater: 1/96 to 2/98

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1)

Occidental of Elk Hills 10800 Stockdale Hwy Bakersfield, CA 93311	Reported: 06/05/2014 13:04 Project: SB4 Sampling Project Number: SB4 Project Manager: Aaron Barbie

Water Analysis (General Chemistry)

BCL Sample ID: 1411084-01 | Client Sample Name: Elk Hills Well 82-2B, 5/17/2014 4:05:00PM, Rick Ogletree

Constituent	Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Electrical Conductivity @ 25 C (Field Test)	27000	umhos/cm	1.0	1.0	EPA-120.1			1
pH (Field Test)	7.23	pH Units	0.05	0.05	EPA-150.1			2
Temperature (Field Test)	87.6	F	32.0	32.0	SM-2550B			3
Total Calcium	650	mg/L	2.0	0.30	EPA-6010B	ND	A10	4
Total Magnesium	230	mg/L	1.0	0.38	EPA-6010B	0.75	A10	4
Total Sodium	4700	mg/L	10	1.0	EPA-6010B	ND	A01	4
Total Potassium	31	mg/L	20	2.6	EPA-6010B	ND	A10	4
Bicarbonate Alkalinity as CaCO3	59	mg/L	8.2	8.2	EPA-310.1	ND		5
Carbonate Alkalinity as CaCO3	ND	mg/L	8.2	8.2	EPA-310.1	ND		5
Hydroxide Alkalinity as CaCO3	ND	mg/L	8.2	8.2	EPA-310.1	ND		5
Total Alkalinity as CaCO3	59	mg/L	8.2	8.2	EPA-310.1	ND		5
Bromide	50	mg/L	5.0	2.2	EPA-300.0	ND	A01	6
Chloride	10000	mg/L	50	6.7	EPA-300.0	20	A01	7
Fluoride	ND	mg/L	2.5	0.70	EPA-300.0	ND	A10	6
Nitrate as NO3	ND	mg/L	22	5.5	EPA-300.0	ND	A10	6
Sulfate	320	mg/L	50	9.0	EPA-300.0	19	A01	6
pH	7.47	pH Units	0.05	0.05	EPA-150.1		S05	8
Electrical Conductivity @ 25 C	26100	umhos/cm	1.00	1.00	EPA-120.1			9
Total Dissolved Solids @ 180 C	20000	mg/L	1000	1000	EPA-160.1	ND		10

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-120.1	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
2	EPA-150.1	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
3	SM-2550B	05/17/14	05/17/14 16:05	REO	Inst	1	BXE2102
4	EPA-6010B	05/23/14	05/27/14 12:45	ARD	PE-OP2	20	BXE2073
5	EPA-310.1	05/20/14	05/20/14 22:52	RML	MET-1	2	BXE1764
6	EPA-300.0	05/19/14	05/19/14 15:23	LD1	IC5	50	BXE1561
7	EPA-300.0	05/19/14	05/19/14 15:36	OLH	IC5	100	BXE1561
8	EPA-150.1	05/20/14	05/20/14 22:52	RML	MET-1	1	BXE1764
9	EPA-120.1	05/20/14	05/20/14 22:52	RML	MET-1	1	BXE1764
10	EPA-160.1	05/20/14	05/20/14 14:00	FRP	MANUAL	100	BXE1775

Groundwater analyses for the 82-2B in the lower Tulare interval

BC Laboratories, Inc.
Environmental Testing Laboratory Since 1949

Occidental of Elk Hills 10800 Stockdale Hwy Bakersfield, CA 93311	**Reported:** 06/05/2014 13:04 Project: SB4 Sampling Project Number: SB4 Project Manager: Aaron Barbie

Metals Analysis

BCL Sample ID: 1411084-01 | **Client Sample Name:** Elk Hills Well 82-2B, 5/17/2014 4:05:00PM, Rick Ogletree

Constituent	Result	Units	PQL	MDL	Method	TTLC Limits	Lab Quals	Run #
Hexavalent Chromium	ND	ug/L	2.0	0.70	EPA-7196		A26,S05	1
Total Antimony	ND	ug/L	2000	170	EPA-6010B	500000	A10	2
Total Arsenic	ND	ug/L	1000	160	EPA-6010B	500000	A10	2
Total Barium	**560**	**ug/L**	**200**	**70**	**EPA-6010B**	10000000	**A10**	2
Total Beryllium	ND	ug/L	200	10	EPA-6010B	75000	A10	2
Total Boron	**5.7**	**mg/L**	**2.0**	**0.26**	**EPA-6010B**		**A10**	2
Total Cadmium	ND	ug/L	200	22	EPA-6010B	100000	A10	2
Total Chromium	ND	ug/L	200	22	EPA-6010B	2500000	A10	2
Total Cobalt	ND	ug/L	1000	26	EPA-6010B	8000000	A10	2
Total Copper	ND	ug/L	200	22	EPA-6010B	2500000	A10	2
Total Lead	ND	ug/L	1000	80	EPA-6010B	1000000	A10	2
Total Lithium	**1.2**	**mg/L**	**0.40**	**0.12**	**EPA-6010B**		**A10**	2
Total Mercury	ND	ug/L	2.0	0.24	EPA-7470A	20000	A10	3
Total Molybdenum	ND	ug/L	1000	24	EPA-6010B	3500000	A10	2
Total Nickel	**67**	**ug/L**	**200**	**40**	**EPA-6010B**	2000000	**J,A10**	2
Total Selenium	**720**	**ug/L**	**2000**	**300**	**EPA-6010B**	100000	**J,A10**	2
Total Silver	ND	ug/L	200	38	EPA-6010B	500000	A10	2
Total Strontium	**17**	**mg/L**	**0.20**	**0.020**	**EPA-6010B**		**A01**	2
Total Thallium	ND	ug/L	2000	480	EPA-6010B	700000	A10	2
Total Vanadium	ND	ug/L	200	44	EPA-6010B	2400000	A10	2
Total Zinc	**49**	**ug/L**	**1000**	**46**	**EPA-6010B**	5000000	**J,A10**	2
Total Recoverable Uranium	ND	pCi/L	3.4	0.34	EPA-200.8		A10	4

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-7196	05/19/14	05/19/14 11:17	TDC	KONE-1	1	BXE1721
2	EPA-6010B	05/23/14	05/27/14 12:45	ARD	PE-OP2	20	BXE2073
3	EPA-7470A	05/27/14	05/29/14 14:17	MEV	CETAC1	10	BXE2194
4	EPA-200.8	05/28/14	05/29/14 11:00	EAR	PE-EL2	5	BXE2298

Groundwater analyses for the 82-2B in the lower Tulare interval

Table 6a. WATER SOURCE WELL #43WS-13B WATER ANALYSIS DATA (mg/kg)				
DATE	6-95	7-95	8-95	9-95
SAMPLE #	95094	95150	95182	95189
CONSTITUENTS:				
Calcium, Ca	230	230	220	220
Magnesium, Mg	85	85	92	93
Sodium, Na	1280	1300	1200	1300
Potassium, K	9.2	9.8	8.8	8.6
Iron, Fe	0.4	0.51	0.38	0.54
Hydroxide, OH	0	0	0	0
Carbonate, CO3	0	0	0	0
Bicarb, HCO3	180	190	190	180
Chloride, Cl	1360	1400	1300	1400
Sulfate, SO4	1600	1600	1500	1600
Sulfide, S	<5.0	<5.0	<5.0	<5.0
Totals	4660	4700	4400	4700
Boron, B	4.7	4.6	4.7	4.7
TDS (Grav)	4890	4800	4900	4900
Hardness, CaCO3	920	920	930	930
Alkalinity, CaCO3	150	160	160	150
Sodium Chloride	3690	3700	3500	3800
pH	7.8	8.1	8.0	7.9
Electrical Conductivity	6.99 mmhos/cm	7.02 mmhos/cm	6.99 mmhos/cm	6.99 mmhos/cm
Specific Gravity	1.003	1.003	1.004	1.003
Resistivity	1.43 ohmm	1.43 ohmm	1.43 ohmm	1.43 ohmm
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

Table 6b. WATER SOURCE WELL #43WS-13B WATER ANALYSIS DATA (mg/kg)				
DATE	10-95	11-95	12-95	
SAMPLE #	95218	95262	95280	
CONSTITUENTS:				
Calcium, Ca	230	230	260	
Magnesium, Mg	96	100	95	
Sodium, Na	1200	1200	1200	
Potassium, K	9.4	9.7	9.1	
Iron, Fe	0.45	0.26	0.3	
Hydroxide, OH	0	0	0	
Carbonate, CO3	0	0	0	
Bicarb, HCO3	180	190	180	
Chloride, Cl	1300	1300	1300	
Sulfate, SO4	1600	1600	1600	
Sulfide, S	<5.0	<5.0	<5.0	
Totals	4600	4600	4500	
Boron, B	4.5	4.9	4.6	
TDS (Grav)	4900	4900	4800	
Hardness, CaCO3	970	990	1000	
Alkalinity, CaCO3	150	160	150	
Sodium Chloride	3600	3700	3500	
pH	7.9	7.8	7.8	
Electrical Conductivity	7.00 mmhos/cm	7.01 mmhos/cm	6.85 mmhos/cm	
Specific Gravity	1.004	1.003	1.003	
Resistivity	1.43 ohmm	1.43 ohmm	1.46 ohmm	
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

TABLE 9 . WATER SOURCE WELL #43WS-13B WATER ANALYSIS DATA 1996

GENERAL MINERALS											
DATE	1/29/96	3/25/96	4/30/96	5/30/96	6/26/96	7/31/96	8/29/96	9/30/96	10/29/96	11/25/96	12/23/96
SAMPLE #	96003	96065	96096	96148	96171	96235	96272	96328	96384	96401	96438
CONSTITUENTS (mg/l)											
Calcium, Ca	270.00	248.00	247.00	249.00	254.00	251.00	246.00	231.00	249.00	258.00	255.00
Magnesium, Mg	100.00	90.00	89.00	89.00	91.00	92.00	90.00	91.00	91.00	92.00	93.00
Sodium, Na	1100.00	1240.00	1160.00	1180.00	1190.00	1230.00	1210.00	1260.00	1200.00	1220.00	1210.00
Potassium, K	9.90	9.40	1.80	8.20	7.80	8.00	8.00	8.10	8.40	8.00	8.40
Iron, Fe	<0.1	0.28	0.32	0.43	0.74	0.55	0.32	0.46	0.33	0.25	0.31
Carbonate, CO_3	0.00	<2.6	<2.6	<2.6	14.50	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	190.00	188.00	180.00	177.00	151.00	177.00	183.00	188.00	177.00	179.00	179.00
Chloride, Cl	1300.00	1400.00	1300.00	1270.00	1280.00	1280.00	1340.00	1320.00	1270.00	1290.00	1190.00
Sulfate, SO_4	1400.00	1680.00	1730.00	1680.00	1640.00	1650.00	1700.00	1680.00	1690.00	1670.00	1560.00
Boron, B	4.80	5.20	4.70	4.90	5.10	4.80	4.60	4.90	4.80	5.00	4.50
TDS (Grav.)	4900.00	4780.00	4660.00	4680.00	4880.00	4900.00	4800.00	4870.00	4850.00	4700.00	4790.00
pH	7.70	7.50	7.90	7.80	8.20	8.20	7.70	7.72	7.77	7.83	7.81
Electrical Conductivity (mohm-meters)	7020.00	7190.00	6900.00	6900.00	7100.00	7080.00	7200.00	7100.00	6980.00	7000.00	7010.00
Specific Gravity (g/cm^3)	1.00	1.01	1.01	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.01
Resistivity (Ohm-meter)	1.42	1.39	1.45	1.45	1.41	1.41	1.39	1.41	1.43	1.43	1.43
ORGANICS											
DATE	6/26/96	6/26/96	6/26/96	6/26/96	12/23/96	12/23/96	12/23/96	12/23/96			
SAMPLE #	96172	96173	96174	96175	96448	96449	96450	96451			
CONSTITUENTS (mg/l)											
Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003			
Toluene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003			
Ethyl Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003			
Total Xylenes	<0.001	<0.001	<0.001	<0.001	<0.0006	<0.0006	<0.0006	<0.0006			

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998

TABLE 8 . WATER SOURCE WELL #43WS-13B WATER ANALYSIS DATA 1997

GENERAL MINERALS	
DATE	1/28/97
SAMPLE #	97013
CONSTITUENTS (mg/l)	
Calcium, Ca	265.00
Magnesium, Mg	98.00
Sodium, Na	1300.00
Potassium, K	8.70
Iron, Fe	0.34
Carbonate, CO_3	<2.6
Bicarbonate, HCO_3	180.00
Chloride, Cl	1340.00
Sulfate, SO_4	1730.00
Boron, B	5.20
TDS (Grav.)	4880.00
pH	7.74
Electrical Conductivity (mohm-meters)	7160.00
Specific Gravity (g/cm^3)	1.003
Resistivity (Ohm-meter)	1.40
ORGANICS	
DATE	6/26/96
SAMPLE #	96172
CONSTITUENT (mg/l)	
Benzene	<0.0005
Toluene	<0.0005
Ethyl Benzene	<0.0005
Total Xylenes	<0.001

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1)

Summary of Groundwater Data, January 1996 through February 1998

Table 7a. WATER SOURCE WELL #84WS-13B WATER ANALYSIS DATA (mg/kg)				
DATE	6-95	7-95	8-95	9-95
SAMPLE #	95099	95151	95183	95190
CONSTITUENTS:				
Calcium, Ca	340	340	330	340
Magnesium, Mg	120	110	130	130
Sodium, Na	1360	1400	1400	1500
Potassium, K	10	10	10	9.5
Iron, Fe	0.61	0.94	0.38	1
Hydroxide, OH	0	0	0	0
Carbonate, CO3	0	0	0	0
Bicarb, HCO3	200	210	210	210
Chloride, Cl	1860	1900	1900	2100
Sulfate, SO4	1480	1500	1500	1500
Sulfide, S	<5.0	<5.0	<5.0	<5.0
Totals	5270	5300	5400	5600
Boron, B	6.2	6.2	6.4	6.6
TDS (Grav)	5550	5500	5600	5600
Hardness, CaCO3	1200	1300	1400	1400
Alkalinity, CaCO3	170	170	170	170
Sodium Chloride	3200	4400	4400	4700
pH	7.5	7.9	7.9	7.8
Electrical Conductivity	8.12 mmhos/cm	8.13 mmhos/cm	8.3 mmhos/cm	8.25 mmhos/cm
Specific Gravity	1.003	1.004	1.004	1.004
Resistivity	1.68 ohmm	1.23 ohmm	1.21 ohmm	1.21 ohmm
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

Table 7b. WATER SOURCE WELL #84WS-13B WATER ANALYSIS DATA (mg/kg)				
DATE	10-95	11-95	12-95	
SAMPLE #	95216	95261	95275	
CONSTITUENTS:				
Calcium, Ca	350	340	410	
Magnesium, Mg	130	130	170	
Sodium, Na	1400	1400	1800	
Potassium, K	11	9.9	13	
Iron, Fe	0.73	0.26	1.6	
Hydroxide, OH	0	0	0	
Carbonate, CO3	0	0	0	
Bicarb, HCO3	210	210	230	
Chloride, Cl	2000	2000	2700	
Sulfate, SO4	1500	1500	1500	
Sulfide, S	<5.0	<5.0	<5.0	
Totals	5400	5400	6700	
Boron, B	6.2	6.7	9.7	
TDS (Grav)	5700	5600	7000	
Hardness, CaCO3	1400	1400	1700	
Alkalinity, CaCO3	170	180	190	
Sodium Chloride	4500	4500	5700	
pH	7.6	7.7	7.5	
Electrical Conductivity	8.29 mmhos/cm	8.36 mmhos/cm	10.46 mmhos/cm	
Specific Gravity	1.004	1.004	1.005	
Resistivity	1.21 ohmm	1.2 ohmm	0.96 ohmm	
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

TABLE 11. WATER SOURCE WELL 284WS-13B WATER ANALYSIS DATA 1996

GENERAL MINERALS										
DATE	1/29/96	2/28/96	3/25/96	6/26/96	7/31/96	8/29/96	9/30/96	10/29/96	11/25/96	12/23/96
SAMPLE #	96004	96051	96066	96176	96234	93270	96327	96383	96404	96437
CONSTITUENTS (mg/l)										
Calcium, Ca	410.00	400.00	288.00	354.00	404.00	389.00	376.00	395.00	413.00	409.00
Magnesium, Mg	140.00	140.00	94.00	118.00	129.00	129.00	134.00	131.00	139.00	143.00
Sodium, Na	1300.00	1500.00	1110.00	1200.00	1270.00	1280.00	1320.00	1310.00	1310.00	1330.00
Chloride, Cl	2000.00	2000.00	1470.00	1830.00	2020.00	2080.00	2100.00	2150.00	2160.00	2200.00
Sulfate, SO_4	1400.00	1700.00	1360.00	1290.00	1310.00	1280.00	1280.00	1300.00	1270.00	1250.00
Boron, B	6.90	6.50	4.70	6.60	7.20	6.40	7.60	7.90	8.10	8.20
TDS (Grav.)	5800.00	5800.00	4550.00	5360.00	5480.00	5540.00	5610.00	5620.00	5500.00	5670.00
pH	7.40	7.80	7.60	8.20	8.10	7.40	7.36	7.15	7.56	7.32
Electrical Conductivity (mohm meters)	8410.00	8430.00	6950.00	8010.00	8240.00	8460.00	8620.00	8600.00	8700.00	8900.00
Specific Gravity (g/cm^3)	1.004	1.004	1.005	1.005	1.004	1.004	1.005	1.006	1.005	1.005
Resistivity (Ohm-meter)	1.19	1.19	1.44	1.25	1.21	1.18	1.16	1.16	1.15	1.12
ORGANICS										
DATE	6/26/96	6/26/96	6/26/96	6/26/96	12/23/96	12/23/96	12/23/96	12/23/96		
SAMPLE #	96177	96178	96179	96180	96444	96445	96446	96447		
CONSTITUENT (mg/l)										
Benzene	0.016	0.015	0.015	0.015	0.028	0.027	0.031	0.031		
Toluene	0.00052	<0.0005	<0.0005	<0.0005	<0.0003	<0.0005	<0.0005	<0.0005		
Ethyl Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0005	<0.0005	<0.0005		
Total Xylenes	<0.001	<0.0005	<0.0005	<0.0005	<0.0006	<0.001	<0.001	<0.001		

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

TABLE 10. WATER SOURCE WELL 284WS-13B WATER ANALYSIS DATA 1997

GENERAL MINERALS					
DATE	1/28/97	2/27/97	3/26/97	8/28/97	10/27/97
SAMPLE #	97012	97043	97072	97224	97385
CONSTITUENTS (mg/l)					
Calcium, Ca	463.00	436.00	428.00	464.00	437.00
Magnesium, Mg	158.00	137.00	137.00	148.00	164.00
Sodium, Na	1440.00	1300.00	1370.00	1570.00	1380.00
Potassium, K	9.00	9.10	8.70	9.70	11.00
Iron, Fe	1.12	0.78	0.87	2.09	3.57
Carbonate, CO_3	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	224.00	215.00	241.00	241.00	237.00
Chloride, Cl	2400.00	2220.00	2150.00	2410.00	2460.00
Sulfate, SO_4	1270.00	1290.00	1240.00	1220.00	1160.00
Boron, B	9.00	8.80	9.20	9.40	10.00
TDS (Grav.)	5870.00	5750.00	5720.00	6230.00	6190.00
pH	7.23	7.11	7.00	7.04	7.09
Electrical Conductivity (mohm-meters)	9310.00	8850.00	8830.00	9350.00	9240.00
Specific Gravity (g/cm^3)	1.004	1.004	1.005	1.004	1.005
Resistivity (Ohm-meter)	1.07	1.13	1.13	1.07	1.10

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

Table 8a. WATER SOURCE WELL #282WS-14B WATER ANALYSIS DATA (mg/kg)				
DATE	6-95	7-95	8-95	9-95
SAMPLE #	95104	95152	95181	95187
CONSTITUENTS:				
Calcium, Ca	320	320	300	310
Magnesium, Mg	81	81	87	87
Sodium, Na	1000	990	980	1000
Potassium, K	7.8	7.9	7.3	7.1
Iron, Fe	<0.1	<0.1	<0.1	<0.1
Hydroxide, OH	0	0	0	0
Carbonate, CO3	0	0	0	0
Bicarb, HCO3	110	120	110	110
Chloride, Cl	1090	1100	1100	1100
Sulfate, SO4	1610	1600	1600	1600
Sulfide, S	<5.0	<5.0	<5.0	<5.0
Totals	4170	4100	4100	4200
Boron, B	4.2	4.2	4.1	4.1
TDS (Grav)	4470	4400	4400	4400
Hardness, CaCO3	1130	1100	1100	1100
Alkalinity, CaCO3	93	98	87	92
Sodium Chloride	3130	3100	3100	3200
pH	7.7	8.0	7.8	7.7
Electrical Conductivity	6.25 mmhos/cm	6.22 mmhos/cm	6.19 mmhos/cm	6.15 mmhos/cm
Specific Gravity	1.003	1.003	1.003	1.003
Resistivity	1.6 ohmm	1.61 ohmm	1.62 ohmm	1.63 ohmm
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

Table 8b. WATER SOURCE WELL #282WS-14B WATER ANALYSIS DATA (mg/kg)				
DATE	10-95	11-95	12-95	
SAMPLE #	95219	95263	95285	
CONSTITUENTS:				
Calcium, Ca	310	320	360	
Magnesium, Mg	87	94	90	
Sodium, Na	980	950	920	
Potassium, K	7.4	8	7.5	
Iron, Fe	<0.1	<0.1	<0.1	
Hydroxide, OH	0	0	0	
Carbonate, CO3	0	0	0	
Bicarb, HCO3	110	110	120	
Chloride, Cl	1100	1100	1100	
Sulfate, SO4	1600	1600	1600	
Sulfide, S	<5.0	<5.0	<5.0	
Totals	4100	4100	4100	
Boron, B	3.9	4.4	4.3	
TDS (Grav)	4500	4400	4400	
Hardness, CaCO3	1100	1200	1300	
Alkalinity, CaCO3	90	94	95	
Sodium Chloride	3100	3100	3000	
pH	7.7	7.7	7.7	
Electrical Conductivity	6.2 mmhos/cm	6.22 mmhos/cm	5.85 mmhos/cm	
Specific Gravity	1.003	1.003	1.003	
Resistivity	1.61 ohmm	1.61 ohmm	1.71 ohmm	
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

TABLE 6 . WATER SOURCE WELL 282WS-14B WATER ANALYSIS DATA 1997

GENERAL MINERALS												
DATE	1/28/97	2/27/97	3/26/97	4/29/97	5/29/97	6/30/97	7/30/97	9/29/97	10/27/97	12/22/97	11/25/96	12/23/96
SAMPLE #	97014	97042	97073	97108	97133	97177	97208	97308	97386	97541	96405	96139
CONSTITUENTS (mg/l)												
Calcium, Ca	364.00	360.00	360.00	365.00	342.00	332.00	337.00	356.00	362.00	383.00	350.00	349.00
Magnesium, Mg	87.00	83.00	82.00	83.00	84.00	84.00	84.00	81.00	89.00	92.00	83.00	83.00
Sodium, Na	990.00	938.00	856.00	976.00	972.00	966.00	954.00	882.00	928.00	1060.00	936.00	940.00
Potassium, K	6.50	7.00	6.70	6.60	7.00	6.50	6.70	8.00	7.80	8.20	6.10	6.60
Iron, Fe	0.171	0.070	0.105	0.126	0.105	0.110	0.086	0.004	0.062	0.127	0.063	0.064
Carbonate, CO_3	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	104.00	103.00	104.00	110.00	111.00	103.00	104.00	105.00	108.00	105.00	106.00	104.00
Chloride, Cl	1100.00	1070.00	1040.00	1080.00	1040.00	1060.00	1040.00	1050.00	1100.00	1000.00	1040.00	1020.00
Sulfate, SO_4	1620.00	1590.00	1560.00	1580.00	1550.00	1600.00	1570.00	1560.00	1600.00	1480.00	1560.00	1540.00
Boron, B	4.40	4.10	4.50	4.40	4.30	3.70	3.90	3.90	4.60	4.30	4.10	3.80
TDS (Grav.)	4260.00	4330.00	4370.00	4430.00	4340.00	4290.00	4340.00	4500.00	4400.00	4340.00	4150.00	4330.00
pH	7.73	7.65	7.64	7.68	7.83	7.66	7.82	7.97	7.60	7.66	7.80	7.77
Electrical Conductivity (mohm-meters)	6210.00	6240.00	6210.00	6250.00	6200.00	6180.00	6200.00	6240.00	6150.00	6160.00	6160.00	6300.00
Specific Gravity (g/cm^3)	1.003	1.005	1.004	1.003	1.004	1.003	1.004	1.006	1.004	1..2	1.003	1.005
Resistivity (Ohm-meter)	1.61	1.60	1.61	1.60	1.61	1.62	1.61	1.60	1.60	1.60	1.43	1.59

ORGANICS												
DATE	6/30/97	6/30/97	6/30/97	6/30/97	12/22/97	12/22/97	12/22/97	12/22/97				
SAMPLE #	97182	97183	97184	97185	97542	97543	97544	97545				
CONSTITUENTS (mg/l)												
Benzene	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003				
Toluene	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003				
Ethyl Benzene	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003				
Total Xylenes	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006				

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

TABLE 7. WATER SOURCE WELL 282WS-14B WATER ANALYSIS DATA 1996

GENERAL MINERALS												
DATE	1/29/96	2/28/96	3/25/96	4/30/96	5/30/96	6/26/96	7/31/96	8/29/96	9/30/96	10/29/96	11/25/96	12/23/96
SAMPLE #	96005	96049	96067	96097	96149	96181	96236	96273	96329	96385	96405	96139
CONSTITUENTS (mg/l)												
Calcium, Ca	370.00	370.00	362.00	354.00	354.00	348.00	355.00	349.00	328.00	345.00	350.00	349.00
Magnesium, Mg	91.00	87.00	81.00	80.00	81.00	80.00	81.00	82.00	80.00	82.00	83.00	83.00
Sodium, Na	980.00	1000.00	930.00	928.00	956.00	925.00	938.00	925.00	970.00	930.00	936.00	940.00
Potassium, K	7.80	7.70	7.20	1.40	6.60	6.10	6.20	6.20	6.20	6.60	6.10	6.60
Iron, Fe	<0.1	<0.1	0.07	0.07	0.10	0.06	0.15	0.09	0.10	0.11	0.06	0.06
Carbonate, CO_3	0.00	0.00	<2.6	<2.6	14.50	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	120.00	100.00	109.00	103.00	124.00	103.00	105.00	100.00	109.00	104.00	106.00	104.00
Chloride, Cl	1200.00	1100.00	1080.00	1100.00	1060.00	1020.00	1020.00	1080.00	1060.00	1040.00	1040.00	1020.00
Sulfate, SO_4	1500.00	1800.00	1580.00	1650.00	1600.00	1540.00	1540.00	1610.00	1600.00	1580.00	1560.00	1540.00
Boron, B	4.20	3.80	4.00	3.90	4.40	4.40	4.00	3.80	4.10	4.20	4.10	3.80
TDS (Grav.)	4500.00	4400.00	4280.00	4240.00	4240.00	4400.00	4360.00	4260.00	4340.00	4380.00	4150.00	4330.00
pH	7.60	7.70	7.80	7.80	7.60	8.00	8.00	7.70	7.72	7.69	7.80	7.77
Electrical Conductivity (mohm meters)	6250.00	6120.00	6100.00	6100.00	6360.00	6170.00	6120.00	6200.00	6210.00	6170.00	6160.00	6300.00
Specific Gravity (g/cm^3)	1.003	1.003	1.005	1.006	1.006	1.003	1.002	1.004	1.005	1.004	1.003	1.005
Resistivity (Ohm-meter)	1.60	1.63	1.64	1.64	1.57	1.62	1.63	1.61	1.61	1.62	1.43	1.59

ORGANICS												
DATE	6/26/96	6/26/96	6/26/96	6/26/96	12/23/96	12/23/96	12/23/96	12/23/96				
SAMPLE #	96182	96183	96184	96185	96452	96453	96454	96455				
CONSTITUENTS (mg/l)												
Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Toluene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Ethyl Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Total Xylenes	<0.001	<0.001	<0.001	<0.001	<0.0006	<0.0006	<0.0006	<0.0006				

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

Attention Mr. Jim White

48-9g

GEOCHEMICAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	6/15/78	WELL NO.	48-9G Int. 1275-1040
DATE OF SAMPLING	5/22/78	COMPANY	Williams Bros. Engineering Company
SAMPLED BY		FIELD	
LABORATORY NO.	3012	ZONE	Flowline while swabbing 5:20 pm
ANALYST		SAMPLE SOURCE	from 900'

RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM +Potassium	Na+K	3921.23	170.49	40.62
CALCIUM	Ca	610.	30.5	7.27
MAGNESIUM	Mg	108.	8.88	2.12
BARIUM	Ba	(-) 1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1800.	37.5	8.93
CHLORIDE	Cl	6049.5	170.89	40.72
CARBONATE	CO_3	-	-	-
BICARBONATE	HCO_3	90.1	1.48	0.35
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	68.		
IRON, ALUMINA	R_2O_3			
TOTAL		12647.	419.7	100.00

GROUP	CHEMICAL CHARACTER		MISCELLANEOUS	
ALKALIS	PRIMARY SALINITY	81.22	BORON	9.4 PPM
EARTHS	SECONDARY SALINITY	18.08	HYDROGEN SULFIDE	less than 0.1 ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	11003 PPM
WEAK ACIDS	SECONDARY ALKALINITY	0.70	RESISTIVITY @ 77°F	0.53 O.M.
Ca/Mg = 3.43			CHLORINITY	9980.0 PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.009
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.5

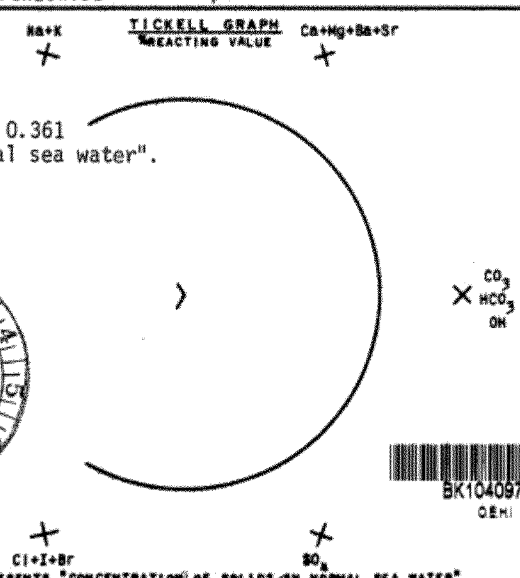
REMARKS

Potassium, K = 36 ppm
Iron, Fe = 17 ppm

Note: The subject water contains 0.361 times the solids content of "normal sea water".

Actual Chloride: 5819.8 ppm

TICKELL GRAPH
% REACTING VALUE



ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

RECEIVED JUN 26 1978 Vault

BK10409727
OEHI

BC Laboratories
3016 Union Avenue
Bakersfield, CA 93305
(805) 325-7475

SIGNED: J. J. Eglin

Groundwater analyses for the 48-9G in the lower Tulare interval

Attention Mr. Jim White

GEOCHEMICAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	6/22/78	WELL NO.	48-9G Int..1265'-1040' Flowline
DATE OF SAMPLING		COMPANY	Williams Bros. Engineering Company
SAMPLED BY	5/23/78	FIELD	
LABORATORY NO.	4042	ZONE	Swabbing 5:25 pm form 900'
ANALYST		SAMPLE SOURCE	

RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM+Potassium	Na +K	3264.2	141.92	39.54
CALCIUM	Ca	568.	28.40	7.91
MAGNESIUM	Mg	94.0	7.73	2.15
BARIUM	Ba	less than 1.		
STRONTIUM	Sr			
Iron	Fe	37.0	1.42	0.40
SULPHATE	SO_4	2016.	42.0	11.70
CHLORIDE	Cl	4816.2	136.05	37.90
CARBONATE	CO_3	-	-	
BICARBONATE	HCO_3	86.6	1.42	0.40
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	80.		
IRON, ALUMINA	R_2O_3			
TOTAL		10062.	358.8	100.00

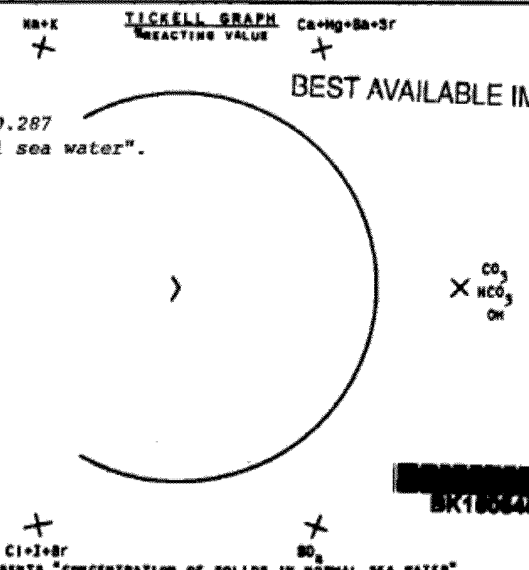
GROUP %	CHEMICAL CHARACTER		MISCELLANEOUS	
ALKALIS	PRIMARY SALINITY	79.08	BORON	6.0 PPM
EARTHS	SECONDARY SALINITY	20.12	HYDROGEN SULFIDE	less than 0.1 ppm
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	8970 PPM
WEAK ACIDS	SECONDARY ALKALINITY	0.80	RESISTIVITY @ 77°F	0.65 O.M.
Ca/~~EARTHS~~ Mg = 3.67			CHLORINITY	7945 PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.007
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.3

REMARKS

Potassium, K = 24 ppm
Iron, Fe = 37 ppm

Note: The subject water contains 0.287 times the solids content of "normal sea water".

TICKELL GRAPH REACTING VALUE



BEST AVAILABLE IMAGE

[redacted]

ABC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

BC Laboratories
3016 UNION AVENUE
BAKERSFIELD, CA 93305
(805) 325-7475

SIGNED: J. J. Eglin

Groundwater analyses for the 48-9G in the lower Tulare interval

CASE E... EERING AND LABORATORY ...
... "A" E. MAIN ST., VENTURA, ... 3003
(805) 653-1327

48-9g

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REPORT OF GEOCHEMICAL ANALYSIS

WILLIAMS BROTHERS ENGINEERING CO.
Well #48-9G Tulare Test
Sampled May 26, 1978 11:30 A.M.
Flowline Sample, Swab Sample

Att: George Elledge

RADICALS	Milligrams Per Liter	Reacting Value	Per Cent
Sodium; A.A.	2900	126.15	-
calc.	3040	132.24	40.82
Potassium	47.2	1.21	0.37
Ammonium	-	-	-
Calcium	375	18.71	5.78
Magnesium	121	9.95	3.07
Barium	TR < 0.2	-	-
Iron (total)	0.5	-	-
Sulfate	1810	37.70	11.64
Chloride	4250	119.89	37.01
Hydroxide	0	0	0
Carbonate	0	0	0
Bicarbonate	247	4.05	1.25
Borate	24	0.31	0.10
Silica	11	-	-
* Organic Acids	-		
Salinity as Salt (NaCl)	-		
Total Solids	9926		

Specific Gravity @ 60° F.

Resistivity 70.3 ohm-cm @ 75° F.

pH Value 6.8

CHEMICAL CHARACTER

Primary Salinity	82.38	%
Secondary Salinity	14.92	%
Primary Alkalinity	0	%
Secondary Alkalinity	2.70	%

*Included in Bicarbonates

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Groundwater analyses for the 48-9G in the lower Tulare interval

48-9g.

GEOCHE[illegible]AL ANALYSIS OF W[illegible]ER Pro-391

DATE OF REPORT	7/31/78	WELL NO.	48-9G 390 BWPD Upper Zone
DATE OF SAMPLING	7/14/78	COMPANY	Williams Bros. Engineering Co.
SAMPLED BY		FIELD	
LABORATORY NO.	5862	ZONE	595 ft 935 ft Flowline Producing
ANALYST		SAMPLE SOURCE	

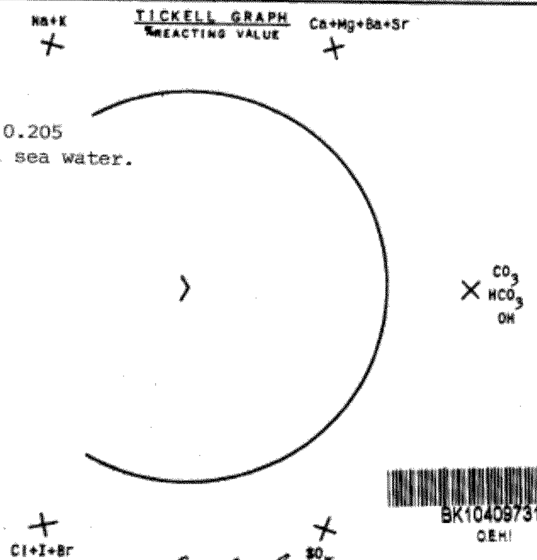
RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM+Potassium	Na+K	2010.0	87.39	37.92
CALCIUM	Ca	310.	15.50	6.73
MAGNESIUM	Mg	150.	12.34	5.35
BARIUM	Ba	less than1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1895.	39.48	17.13
CHLORIDE	Cl	2584.9	73.02	31.68
CARBONATE	CO_3	-	-	-
BICARBONATE	HCO_3	166.3	2.73	1.19
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	52.0		
IRON, ALUMINA	R_2O_3			
TOTAL		7168.	230.5	100.00

GROUP	CHEMICAL CHARACTER		MISCELLANEOUS		
ALKALIS	PRIMARY SALINITY	75.84	BORON	8.2	PPM
EARTHS	SECONDARY SALINITY	21.78	HYDROGEN SULFIDE	less than 0.1 ppm	
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	6050.2	PPM
WEAK ACIDS	SECONDARY ALKALINITY	2.38	RESISTIVITY @ 77°F	0.97	O.M.
Ca/~~EARTHS~~ Mg = 1.26			CHLORINITY	4264.4	PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.008	
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.6	

REMARKS

Potassium, K = 17 ppm
Iron, Fe = 1.2 ppm

Note: The subject water contains 0.205 times the solids content of normal sea water.



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3016 UNION AVENUE
BAKERSFIELD, CA 93305 (805) 325-7475

ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

SIGNED: J. J. Eglin

BK10409731
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Groundwater analyses for the 48-9G in the upper Tulare interval

Attention Mr. G[illegible]e Elledge

48-9g

GE[illegible]CAL ANALYSIS OF WATER Pro-391

DATE OF REPORT	8/16/78	WELL NO.	48-0G Flowline Upper Zone 48-9G
DATE OF SAMPLING	7/14/78 2:15 pm	COMPANY	Williams Bros. Engineering Co.
SAMPLED BY		FIELD	
LABORATORY NO.	6018	ZONE	Tulare Sand
ANALYST		SAMPLE SOURCE	

RADICALS		PARTS PER MILLION MILLIGRAMS PER LITER	REACTING VALUE EQUIVALENTS PER MILLION	REACTING VALUE PERCENT
SODIUM+Potassium	Na+K	2111.2	91.79	38.15
CALCIUM	Ca	340.	17.0	7.07
MAGNESIUM	Mg	140.	11.51	4.78
BARIUM	Ba	less than1.		
STRONTIUM	Sr			
SULPHATE	SO_4	1880.	39.16	16.28
CHLORIDE	Cl	2775.7	78.41	32.59
CARBONATE	CO_3	0	0	0
BICARBONATE	HCO_3	166.3	2.73	1.13
HYDROXIDE	OH			
IODIDE	I			
SILICA	SiO_2	40.		
IRON, ALUMINA	R_2O_3			
TOTAL		7453.	240.6	100.00

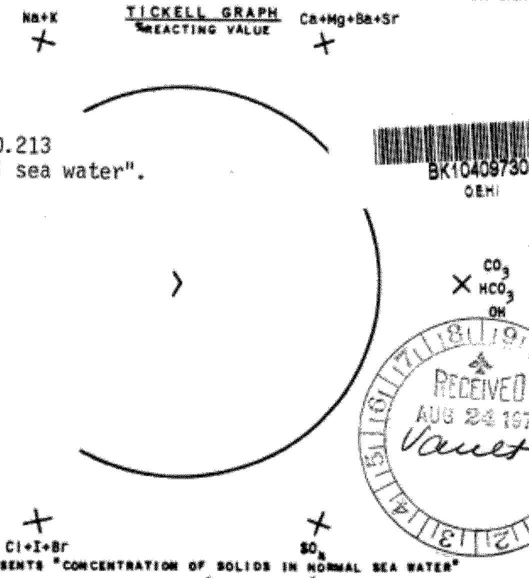
GROUP	CHEMICAL CHARACTER		MISCELLANEOUS		
ALKALIS	PRIMARY SALINITY	76.30	BORON	9.4	PPM
EARTHS	SECONDARY SALINITY	21.44	HYDROGEN SULFIDE	less than 0.1 ppm	
STRONG ACIDS	PRIMARY ALKALINITY	-	EQUIVALENT SALT	6050	PPM
WEAK ACIDS	SECONDARY ALKALINITY	2.26	RESISTIVITY @ 77°F	0.97	O.M.
Ca/~~XXXXXX~~ Mg = 1.48			CHLORINITY	4579	PPM
CHLORIDE SALINITY			SPECIFIC GRAVITY	1.020	
SULPHATE SALINITY	CARBONATE/CHLORIDE		pH	7.2	

REMARKS

Potassium, K = 19 ppm
Iron, Fe = 0.12 ppm

Note: The subject water contains 0.213 times the solids content of "normal sea water".

TICKELL GRAPH
% REACTING VALUE



ARC REPRESENTS "CONCENTRATION OF SOLIDS IN NORMAL SEA WATER"

BK10409730
OEHI

MATERIAL & SERVICE RELEASE/RECEIVING

PRODUCTION WELL NO. 48-9G
DRILLING WELL NO.
M E J NO.
OTHER

I certify that all indicated services have been performed and/or all materials received.

By S. Elledge Date 8/25/78

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BC Laboratories
3016 UNION AVENUE
BAKERSFIELD, CA 93305
(805) 325-7475

SIGNED: J. J. Eglin

Groundwater analyses for the 48-9G in the upper Tulare interval

UO-NPR #1, ELK HILLS
35R LABORATORY SERVICES

GEOCHEMICAL WATER ANALYSIS

Distribution:
Lab files (original)
Well files
Chevron engineering
Radonna George
Dave Lefler
Dan Scarberry

Geochem No. : 2890
SAMPLE DATE : 11/25/91
SAMPLE LOCATION: 45WS-18G
SAMPLE SOURCE : SOURCE WELL
SAMPLED BY : OPERATOR
REPORTED BY : ED
REQUESTED BY : MILT DREWBLOW

****

CONSTITUENTS		MILLIGRAMS PER LITER (mg/l)	MILLIEQUIVALENTS PER LITER (meq/l)	PERCENT OF TOTAL MILLIEQUIVALENTS (%)	METHOD
CATIONS					
Sodium	Na	1386.	60.3	33.72	AA
Potassium	K	72.2	1.8	1.03	AA
Calcium	Ca	322.	16.1	8.99	AA
Magnesium	Mg	110.	9.0	5.06	AA
Barium	Ba	3.8	0.06	0.03	AA
Strontium	Sr	6.8	0.16	0.09	AA
Iron	Fe	1.2			AA
Silicon	Si	27.4			AA
Boron	B	17.0			AA
ANIONS					
Chloride	Cl	2381.	67.2	37.58	Titr.
Bicarbonate	HCO3	220.	3.6	2.01	Titr.
Carbonate	CO3	N.D.	N.D.	0.00	Titr.
Hydroxide	OH	N.D.	N.D.	0.00	Titr.
Sulfate	SO4	986.	20.5	11.48	Turb.
Silica	SiO2	58.6			Calc.
Borate	BO3	92.5			Calc.
Phosphate	PO4	58.7			Color.

pH : 7.7
Spec. Grav.(60°F) : 1.004
Ca(meq)/Mg(meq) : 1.78
Hardness (mg/l CaCO3) : 1256.
Total Dis. Solid(mg/l): 5600.
(From Spec. Grav.)
Total Dis. Solid(mg/l): 5698.
(From Analysis)
Sum of Cations(meq/l) : 87.4
Sum of Anions (meq/l) : 91.3

PALMER VALUES (%)
Primary Salinity: 71.04
Secondary Salinity: 25.02
Tertiary Salinity: 0.00
Primary Alkalinity: 0.00
Secondary Alkalinity: 3.94

****

N/A: Not Available   N.D.: Not Detected

REMARKS:

Form: 17-031 (8-10-89)

BK15454349

Tulare groundwater analyses for the 45WS-18G

GEOCHEMICAL WATER ANALYSIS

Lab. No.

Date of Sampling: 8/26/1982	Sample Location: 86 W-18G
Date of Analysis: 8/26/1982	Sample Source:
Sampled by: Tom White	
Analyst: Binh & Delores	Requested by: Russ Lippert

1. pH 7.28 2. Temp(°F) 99.5	9. Calculated Dis. Solid(mg/l) 5351	Palmer Value (%)
3. Spec. Grav. (60°F) 1.005	10. Estimated Dis. Solid(mg/l) 7000	16. Primary Salinity 67.04
4. Resistivity(Ωm) 1.50 @ 75°F	11. Estimated Dis. NaCl(ppm) 3,800	17. Secondary Salinity 29.76
5. H_2S (mg/l)	12. Suspended Solid(mg/l)	18. Tertiary Salinity
6. Boron (mg/l)	13. Organic Acid(meq/l)	19. Primary Alkalinity -0-
7. Iron (mg/l) 0.85	14. Ca/Mg 17.09	20. Secondary Alkalinity 1.60
8. Total Hardness (mg/l as $CaCO_3$) 1339	15. SRB	

CATION	mg/l	meq/l	% meq/l	ANION	mg/l	meq/l	% meq/l
Ca	507.0	25.30	15.57	HCO_3	158.0	2.60	1.60
Mg	18.00	1.48	0.91	CO_3	—	—	—
Ba				OH	—	—	—
Sr				SO_4	2400	50.00	30.78
Na	1252	54.45	33.52	Cl	1015	28.63	17.62
K							
Total					5351	162.46	100.00

Remarks:

BK15031626

Signed: Binh Nguyen Date: 8/26/1982

Tulare groundwater analyses for the 86W-18G

GEOCHEMICAL WATER ANALYSIS

Vt (Put in file)

Date of Sampling: 1/20/1984
Date of Analysis: 1/20/1984
Sampled By : Jodie Brown
Analyzed By : Binh Nguyen

Sample Location: [redacted]
Sample Source :
Requested By : Jodie Brown

pH 7.5 Temp. (°F)	Calculated Dis. Solid (mg/l) 5842	Palmer Value (%)
Spec. Grav. (60°F) 1.006	Estimated Dis. Solid (mg/l) 8,300	Primary Salinity 72.80
Resistivity (ohm) @ °F	Estimated Dis. NaCl (ppm)	Secondary Salinity 24.11
H_2S (mg/l)	Suspended Solid (mg/l)	Tertiary Salinity
Boron (mg/l)	Organic Acid (meq/l)	Primary Alkalinity
Iron (mg/l) 1.0	Ca/Mg 10.50	Secondary Alkalinity 3.09
Total Hardness (mg/l as $CaCO_3$) 1197	SRB	

CATION	mg/l	meq/l	% meq/l	ANION	mg/l	meq/l	% meq/l
Ca	437.7	21.84	12.42	HCO_3	166.0	2.72	1.55
Mg	25.28	2.08	1.18	CO_3		–	
Ba				OH		–	
Sr				SO_4	2750	57.25	32.55
Na	1472	64.02	36.40	Cl	991.6	27.97	15.90
K				TOTAL	5842	175.9	100.00

Remarks:

BK10900869
IRON MOUNTAIN

Signed: Date:

Tulare

Tulare groundwater analyses for the 86W-18G

Table 9a. WATER SOURCE WELL #86WS-18G
WATER ANALYSIS DATA (mg/kg)

DATE	6-95	7-95	8-95	9-95
SAMPLE #	95109	95153	95184	95191
CONSTITUENTS:				
Calcium, Ca	350	335	330	330
Magnesium, Mg	78	75	84	82
Sodium, Na	1020	1000	1000	1100
Potassium, K	7.7	8	7.2	7
Iron, Fe	<0.1	0.2	<0.1	<0.1
Hydroxide, OH	0	0	0	0
Carbonate, CO3	0	0	0	0
Bicarb, HCO3	130	130	130	130
Chloride, Cl	1300	1300	1300	1400
Sulfate, SO4	1440	1400	1400	1400
Sulfide, S	<5.0	<5.0	<5.0	<0.5
Totals	4260	4200	4200	4300
Boron, B	5.6	5.5	5.6	5.5
TDS (Grav)	4540	4400	4500	4500
Hardness, CaCO3	1195	1100	1200	1200
Alkalinity, CaCO3	100	110	110	100
Sodium Chloride	3270	3200	3200	3400
pH	7.6	7.9	7.9	7.6
Electrical Conductivity	6.48 mmhos/cm	6.37 mmhos/cm	6.4 mmhos/cm	6.35 mmhos/cm
Specific Gravity	1.004	1.003	1.003	1.003
Resistivity	1.54 ohmm	1.57 ohmm	1.56 ohmm	1.58 ohmm

NOTE: Sample analysis is from Zalco Laboratory.

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

Table 9b. WATER SOURCE WELL #86WS-18G WATER ANALYSIS DATA (mg/kg)				
DATE	10-95	11-95	12-95	
SAMPLE #	95220	95264	95290	
CONSTITUENTS:				
Calcium, Ca	320	340	380	
Magnesium, Mg	81	88	86	
Sodium, Na	1000	920	930	
Potassium, K	7.4	7.7	7.8	
Iron, Fe	0.22	<0.1	<0.1	
Hydroxide, OH	0	0	0	
Carbonate, CO3	0	0	0	
Bicarb, HCO3	130	130	130	
Chloride, Cl	1200	1200	1200	
Sulfate, SO4	1400	1400	1400	
Sulfide, S	<5.0	<5.0	<5.0	
Totals	4100	4000	4100	
Boron, B	5	5.8	5.6	
TDS (Grav)	4500	4400	4400	
Hardness, CaCO3	1100	1200	1300	
Alkalinity, CaCO3	100	110	110	
Sodium Chloride	3200	3100	3100	
pH	7.7	7.6	7.6	
Electrical Conductivity	6.35 mmhos/cm	6.31 mmhos/cm	6.34 mmhos/cm	
Specific Gravity	1.003	1.003	1.003	
Resistivity	1.58 ohmm	1.58 ohmm	1.58 ohmm	
NOTE: Sample analysis is from Zalco Laboratory.				

(Source: NPR-1 Ground Water Monitoring Plan, 1995)

TABLE 13. WATER SOURCE WELL 86WS-18G WATER ANALYSIS DATA 1996

GENERAL MINERALS												
DATE	1/29/96	2/28/96	3/25/96	4/30/96	5/30/96	6/26/96	7/31/96	8/29/96	9/30/96	10/29/96	11/25/96	12/23/96
SAMPLE #	96006	96048	96068	96095	96147	96186	96233	96269	96326	96382	96403	96436
CONSTITUENTS (mg/l)												
Calcium, Ca	390.00	380.00	366.00	365.00	377.00	375.00	399.00	360.00	359.00	369.00	378.00	374.00
Magnesium, Mg	86.00	86.00	79.00	78.00	80.00	79.00	82.00	82.00	81.00	83.00	84.00	83.00
Sodium, Na	960.00	1000.00	940.00	928.00	964.00	920.00	962.00	954.00	996.00	947.00	954.00	942.00
Potassium, K	7.30	7.80	7.20	6.30	6.70	6.20	6.30	6.30	6.20	6.70	6.20	6.60
Iron, Fe	<0.1	<0.1	0.07	0.09	0.11	0.12	0.19	0.17	0.44	1.45	0.82	0.28
Carbonate, CO_3	0.00	0.00	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	130.00	130.00	269.00	131.00	103.00	124.00	124.00	128.00	132.00	122.00	123.00	126.00
Chloride, Cl	1400.00	1200.00	1450.00	1260.00	1190.00	1180.00	1230.00	1300.00	1270.00	1260.00	1270.00	1240.00
Sulfate, SO_4	1300.00	1600.00	1230.00	1500.00	1410.00	1380.00	1420.00	1470.00	1400.00	1440.00	1430.00	1430.00
Boron, B	5.50	5.30	5.50	5.20	5.60	5.30	5.70	5.30	5.70	5.70	5.60	5.60
TDS (Grav.)	4400.00	4500.00	4250.00	4230.00	4330.00	4500.00	4460.00	4540.00	4450.00	4500.00	4400.00	4420.00
pH	7.50	7.70	7.50	7.60	7.80	8.10	8.00	7.50	7.52	7.42	7.71	7.60
Electrical Conductivity (mohm-meters)	6330.00	6370.00	6300.00	6280.00	6150.00	6380.00	6400.00	6480.00	6480.00	6440.00	6410.00	6510.00
Specific Gravity (g/cm^3)	1.003	1.003	1.005	1.007	1.006	1.003	1.004	1.004	1.004	1.005	1.005	1.005
Resistivity (Ohm-meter)	1.58	1.57	1.59	1.59	1.63	1.57	1.56	1.54	1.54	1.55	1.56	1.54

ORGANICS												
DATE	6/26/96	6/26/96	6/26/96	6/26/96	12/23/96	12/23/96	12/23/96	12/23/96				
SAMPLE #	96182	96183	96184	96185	96452	96453	96454	96455				
CONSTITUENT (mg/l)												
Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Toluene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Ethyl Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0003	<0.0003	<0.0003				
Total Xylenes	<0.001	<0.001	<0.001	<0.001	<0.0006	<0.0006	<0.0006	<0.0006				

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

TABLE 12 . WATER SOURCE WELL 86WS-18G WATER ANALYSIS DATA
1997

GENERAL MINERALS											
DATE	1/28/97	2/27/97	3/26/97	4/29/97	5/29/97	6/30/97	7/30/97	8/28/97	9/29/97	10/27/97	12/22/97
SAMPLE #	97011	97041	97071	97107	97134	97176	97207	97223	97310	97387	97539
CONSTITUENTS (mg/l)											
Calcium, Ca	454.00	397.00	400.00	397.00	378.00	375.00	381.00	398.00	407.00	387.00	411.00
Magnesium, Mg	89.00	86.00	85.00	82.00	89.00	88.00	89.00	88.00	87.00	98.00	94.00
Sodium, Na	1010.00	970.00	1010.00	998.00	996.00	966.00	983.00	1010.00	892.00	960.00	1060.00
Potassium, K	6.70	7.20	6.80	6.30	7.10	6.70	7.00	7.10	7.50	9.00	7.60
Iron, Fe	0.560	0.146	0.239	0.104	0.057	0.205	0.078	0.109	<0.25	0.087	0.079
Carbonate, CO_3	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Bicarbonate, HCO_3	123.00	125.00	124.00	128.00	128.00	127.00	111.00	163.00	129.00	133.00	129.00
Chloride, Cl	1330.00	1340.00	1300.00	1310.00	1270.00	1340.00	1310.00	1370.00	1370.00	1410.00	1260.00
Sulfate, SO_4	1490.00	1440.00	1420.00	1420.00	1350.00	1430.00	1390.00	1440.00	1410.00	1430.00	1300.00
Boron, B	5.80	5.90	6.10	6.00	6.00	5.70	5.60	5.90	5.60	6.80	6.10
TDS (Grav.)	4400.00	4480.00	4540.00	4620.00	4460.00	4520.00	4510.00	4560.00	4680.00	4620.00	4530.00
pH	7.52	7.50	7.45	7.57	7.86	7.72	7.63	7.51	7.93	7.64	7.49
Electrical Conductivity (mohm-meters)	6500.00	6610.00	6640.00	6670.00	6660.00	6600.00	6650.00	6770.00	6700.00	6630.00	6630.00
Specific Gravity (g/cm^3)	1.004	1.005	1.004	1.004	1.004	1.003	1.004	1.004	1.005	1.004	1.004
Resistivity (Ohm-meter)	1.54	1.51	1.51	1.50	1.50	1.52	1.50	1.48	1.49	1.50	1.50

ORGANICS											
DATE	6/30/97	6/30/97	6/30/97	6/30/97	12/22/97	12/22/97	12/22/97	12/22/97			
SAMPLE #	97178	97179	97180	97181	97538	97535	97536	97537			
CONSTITUENTS (mg/l)											
Benzene	0.00051	0.0004	0.00035	0.00046	<0.0003	<0.0003	0.00036	0.00038			
Toluene	0.00052	0.00071	0.00061	0.00066	<0.0003	<0.0003	<0.0003	<0.0003			
Ethyl Benzene	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003			
Total Xylenes	<0.0006	<0.0003	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006			

(Source: Ground Water Monitoring Plan for Naval Petroleum Reserve No. 1, Summary of Data, January 1996 through February 1998)

CO-NPR #1, ELK HILLS
35R LABORATORY SERVICES

GEOCHEMICAL WATER ANALYSIS

Distribution:	
Lab files (original)	Geochem No. : 2521
Well files	SAMPLE DATE : 10-02-90
Chevron engineering	SAMPLE LOCATION: 284WS-13B
Radonna George	SAMPLE SOURCE : SOURCE WELL
Dave Lefler	SAMPLED BY : N/A
Dan Scarberry	REPORTED BY : BINH NGUYEN
Dan Harms	REQUESTED BY : DAN GEARY

****

CONSTITUENTS		MILLIGRAMS PER LITER (mg/l)	MILLIEQUIVALENTS PER LITER (meq/l)	PERCENT OF TOTAL MILLIEQUIVALENTS (%)	METHOD
CATIONS					
Sodium	Na	1461.	63.5	35.90	AA
Potassium	K	53.8	1.4	0.78	AA
Calcium	Ca	255.	12.7	7.20	AA
Magnesium	Mg	98.0	8.1	4.55	AA
Barium	Ba	5.6	0.08	0.05	AA
Strontium	Sr	5.0	0.11	0.06	AA
Iron	Fe	0.08			AA
Silicon	Si	23.0			AA
Boron	B	18.0			AA
ANIONS					
Chloride	Cl	1968.	55.5	31.37	Titr.
Bicarbonate	HCO3	178.	2.9	1.65	Titr.
Carbonate	CO3	N.D.	N.D.	0.00	Titr.
Hydroxide	OH	N.D.	N.D.	0.00	Titr.
Sulfate	SO4	1567.	32.6	18.44	Turb.
Silica	SiO2	49.2			Calc.
Borate	BO3	97.9			Calc.
Phosphate	PO4	~~5.2~~			~~Color.~~

pH :	7.2	PALMER VALUES (%)	
Spec. Grav.(60°F) :	1.006	Primary Salinity:	75.56
Ca(meq)/Mg(meq) :	1.58	Secondary Salinity:	21.24
Hardness (mg/l CaCO3) :	1040.	Tertiary Salinity:	0.00
Total Dis. Solid(mg/l): (From Spec. Grav.)	8300.	Primary Alkalinity:	0.00
Total Dis. Solid(mg/l): (From Analysis)	5744.	Secondary Alkalinity:	3.21
Sum of Cations(meq/l) :	85.9		
Sum of Anions (meq/l) :	91.1		

****

N/A: Not Available N.D.: Not Detected

REMARKS:

Resistivity (ohm-m)(77 °F): 1.15 ===> TDS (ppm as NaCl): 4700
% Difference of Cations and Anions: 6.0

Form: 17-031 (8-10-89)

BK10481467
OEHI

Tulare groundwater analyses for the 284WS-13B

UO-NPR #1, ELK HILLS
35R LABORATORY SERVICES

GEOCHEMICAL WATER ANALYSIS

Distribution:
Lab files (original)
Well files
Chevron engineering
Radonna George
Dave Lefier
Dan Scarberry

Geochem No.	:	2877
SAMPLE DATE	:	10/17/91
SAMPLE LOCATION	:	284WS-13B
SAMPLE SOURCE	:	SOURCE WELL
SAMPLED BY	:	TERRAZZAS
REPORTED BY	:	ED
REQUESTED BY	:	LIPPERT/SMITH/SERGENT

CONSTITUENTS		MILLIGRAMS PER LITER (mg/l)	MILLIEQUIVALENTS PER LITER (meq/l)	PERCENT OF TOTAL MILLIEQUIVALENTS (%)	METHOD
CATIONS					
Sodium	Na	1094.	47.6	34.13	AA
Potassium	K	4.4	0.11	0.08	AA
Calcium	Ca	292.	14.6	10.45	AA
Magnesium	Mg	92.4	7.6	5.45	AA
Barium	Ba	17.0	0.25	0.18	AA
Strontium	Sr	5.6	0.13	0.09	AA
Iron	Fe	0.01			AA
Silicon	Si	24.7			AA
Boron	B	4.2			AA
ANIONS					
Chloride	Cl	1294.	36.5	26.19	Titr.
Bicarbonate	HCO3	159.	2.6	1.86	Titr.
Carbonate	CO3	N.D.	N.D.	0.00	Titr.
Hydroxide	OH	N.D.	N.D.	0.00	Titr.
Sulfate	SO4	1444.	30.1	21.57	Turb.
Silica	SiO2	52.9			Calc.
Borate	BO3	22.9			Calc.
Phosphate	PO4	22.0			Color.

pH : 8.0
Spec. Grav.(60°F) : 1.004
Ca(meq)/Mg(meq) : 1.92
Hardness (mg/l CaCO3) : 1108.
Total Dis. Solid(mg/l): 5600.
(From Spec. Grav.)
Total Dis. Solid(mg/l): 4500.
(From Analysis)
Sum of Cations(meq/l) : 70.2
Sum of Anions (meq/l) : 69.2

PALMER VALUES (%)
Primary Salinity: 67.90
Secondary Salinity: 28.34
Tertiary Salinity: 0.00
Primary Alkalinity: 0.00
Secondary Alkalinity: 3.76

N/A: Not Available N.D.: Not Detected

REMARKS:

Form: 17-031 (8-10-89)

BK15031117

Tulare groundwater analyses for the 284WS-13B

Exhibit 28

Tulare Water Source Well Location Map

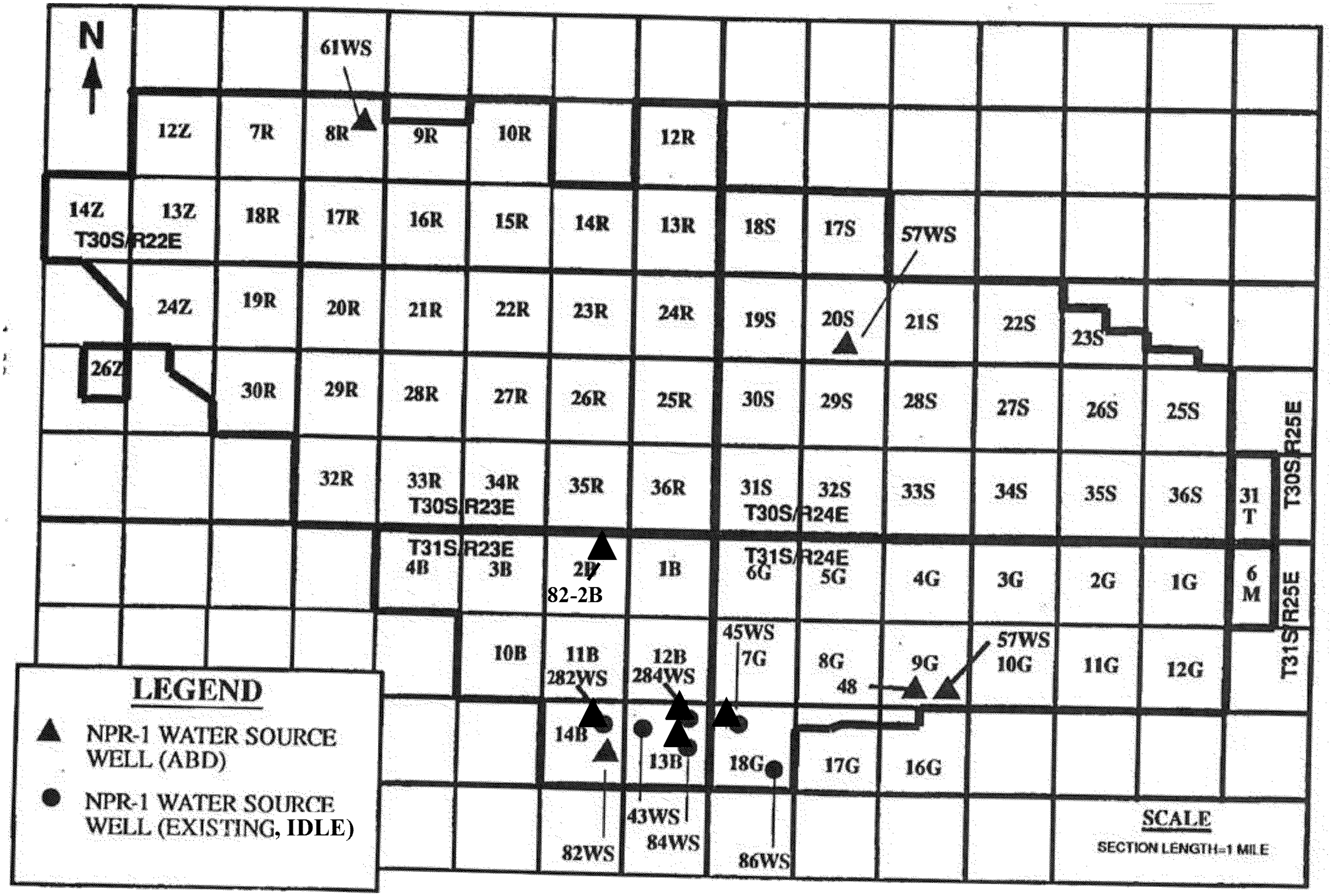

N
61WS
12Z
7R
8R
9R
10R
12R
14Z
13Z
T30S/R22E
18R
17R
16R
15R
14R
13R
18S
17S
57WS
24Z
19R
20R
21R
22R
23R
24R
19S
20S
21S
22S
23S
26Z
30R
29R
28R
27R
26R
25R
30S
29S
28S
27S
26S
25S
32R
33R
34R
T30S/R23E
35R
36R
31S
32S
T30S/R24E
33S
34S
35S
36S
31
T
T30S/R25E
T31S/R23E
4B
3B
2B
82-2B
1B
T31S/R24E
6G
5G
4G
3G
2G
1G
6
M
T31S/R25E
10B
11B
282WS
12B
284WS
45WS
7G
8G
9G
48
57WS
10G
11G
12G
14B
13B
18G
17G
16G
82WS
43WS
84WS
86WS
LEGEND
NPR-1 WATER SOURCE WELL (ABD)
NPR-1 WATER SOURCE WELL (EXISTING, IDLE)
SCALE
SECTION LENGTH=1 MILE

Exhibit 29

Regional Map of TDS in Groundwater

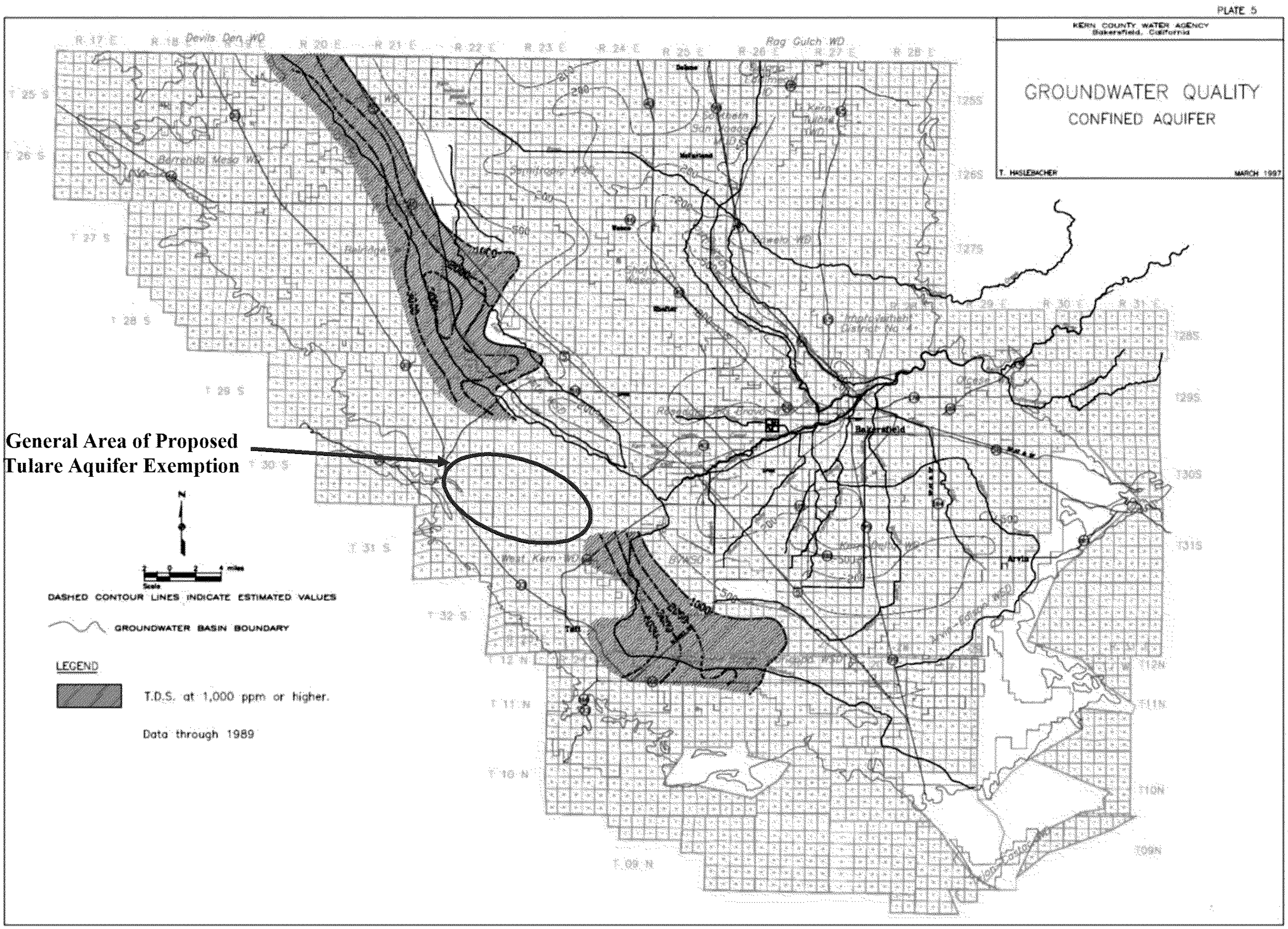


PLATE 5
KERN COUNTY WATER AGENCY
Bakersfield, California
GROUNDWATER QUALITY
CONFINED AQUIFER
T. HASLEBACHER
MARCH 1997
General Area of Proposed
Tulare Aquifer Exemption
DASHED CONTOUR LINES INDICATE ESTIMATED VALUES
GROUNDWATER BASIN BOUNDARY
LEGEND
T.D.S. at 1,000 ppm or higher.
Data through 1989
Bakersfield
Devils Den WD
Rag Gulch WD
Berrenda Mesa WD
West Kern WD

F

Exhibit 30[23]

Comparison of Measured and Calculated Salinities

[23] Discussion of salinity calculation method and all geologic work in this exhibit was prepared by Mr. Stephen A. Reid of OEHI, California-licensed Professional Geologist No. 3876.

SALINITY CALCULATION METHOD

Calculation of salinity is a four step process: (1) converting measured density to formation porosity, (2) calculation of apparent water resistivity using the Humble equation, (3) correcting apparent water resistivity to a standard temperature, and (4) converting temperature corrected apparent water resistivity to salinity.

For step 1, the equation to convert measured density to porosity is:

POR = (Rhom - RHOB) /(Rhom-Rhof)

Parameter definitions for the equation are:

POR is formation porosity
Rhom is formation matrix density (g/cc); 2.65 g/cc is used for sandstones
RHOB is calibrated bulk density taken from well log measurements (g/cc)
Rhof is fluid density (g/cc); 1.00 g/cc is used for water-filled porosity

For step 2, the Humble equation calculates apparent water resistivity. The equation as described by Davis (1988) is:

Rwah = ((PORm) * XRESD)/a**

Parameter definitions for the equation are:

Rwah is apparent water resistivity (ohmm)
POR is formation porosity as derived from the density conversion formula
m is the cementation factor; 2.15 is the standard value used in the Humble equation
XRESD is deep reading formation resistivity taken from well log measurements (ohmm)
a is the Archie constant; 0.62 is the standard value used in the Humble equation

For step 3, Humble apparent water resistivity is corrected from formation temperature to a surface temperature standard of 75°F:

Rwahc = Rwah * ((TEMP)+6.77)/(75+6.77)

Parameter definitions for the equation are:

Rwahc is apparent water resistivity (ohmm), corrected to surface temperature
TEMP is downhole temperature based on temperature gradient (°F)

Step 4 is the conversion of corrected apparent water resistivity to salinity. There are two ways to accomplish this: either by using a nomograph from a standard industry chart book (Schlumberger, 1978, Chartbook GEN-9). A formula may also be used for the conversion (from Baker Hughes, 2002, introduction to Wireline Log Analysis, p. 111):

SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)

Parameter definitions for the equation are:

SAL_h is salinity from corrected Rwahc (ppm)
Rwahc is apparent water resistivity, corrected to surface temperature (ohmm), calculated above

As a demonstration of the four-step calculation process, salinity for Sand 86E-2 is calculated at 1020' (md) in well 86E-34R. For the calculations, input parameters from the wellbore logs are:

RHOB = 2.184 g/cc
TEMP = 90.4°F
XRESD = 2.136 ohmm

For step 1, the equation to convert measured density to porosity is:

POR = (Rhom - RHOB) /(Rhom-Rhof)

POR = (2.65 - RHOB) /(2.65 - 1.0)
= (2.65 - 2.184)/(2.65 - 1.0)
= 0.2824
= 28.2% porosity

For step 2, the Humble equation calculates apparent water resistivity:

Rwah = ((POR**m) * XRESD)/a

Rwah = ((POR**2.15) * XRESD)/0.62
= ((0.2824**2.15) * 2.136)/0.62
= 0.227 ohmm @ 90.4°F

For step 3, Humble apparent water resistivity is corrected from formation temperature to a surface temperature standard:

Rwahc = Rwah * ((TEMP)+6.77)/(75+6.77)

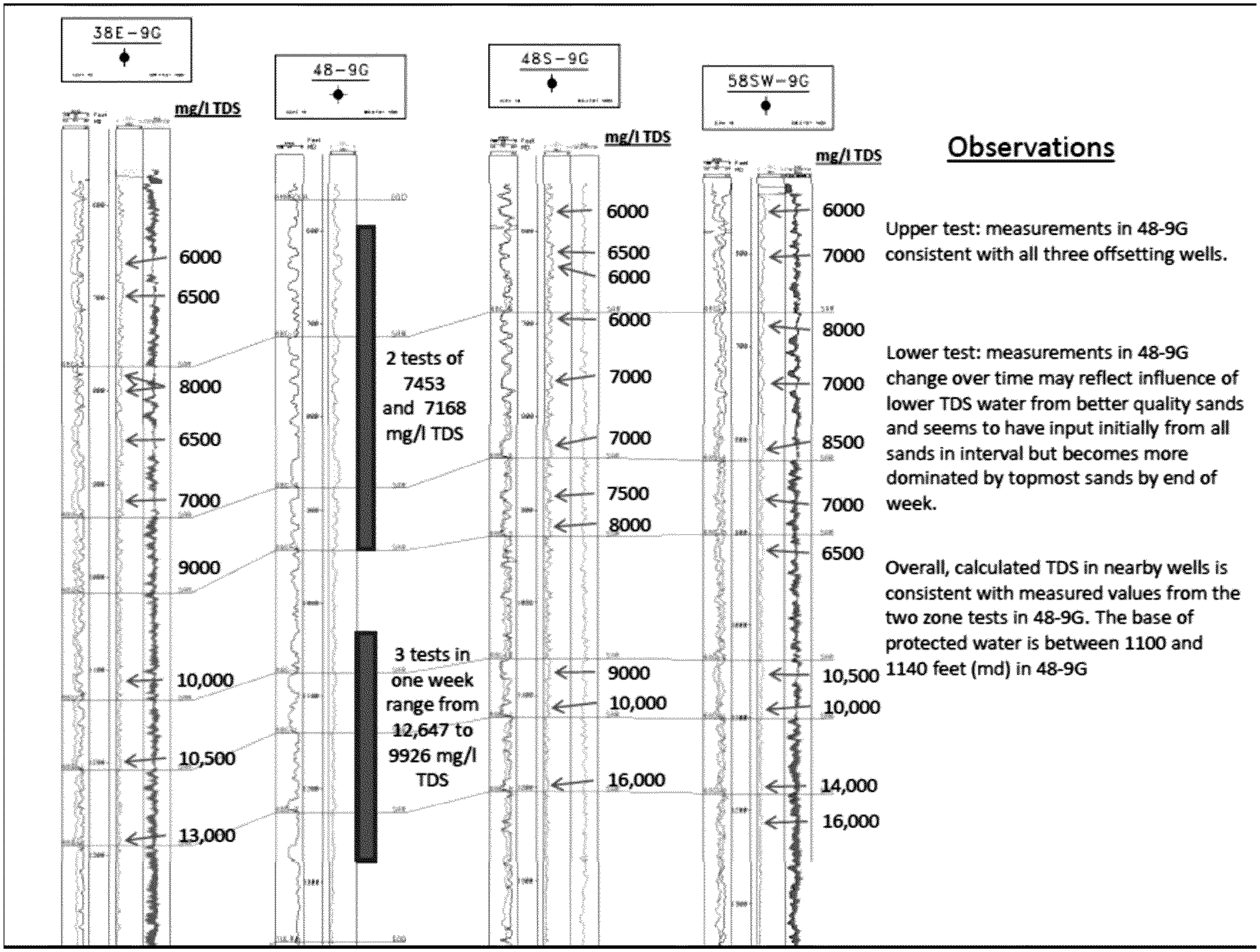
Rwahc = Rwah * (TEMP)+6.77)/(75+6.77)
= 0.227 * (90.4 +6.77)/(75+6.77)
= 0.269 ohmm @ 75°F

For step 4, the formula method is used for the conversion of corrected apparent water resistivity to salinity.

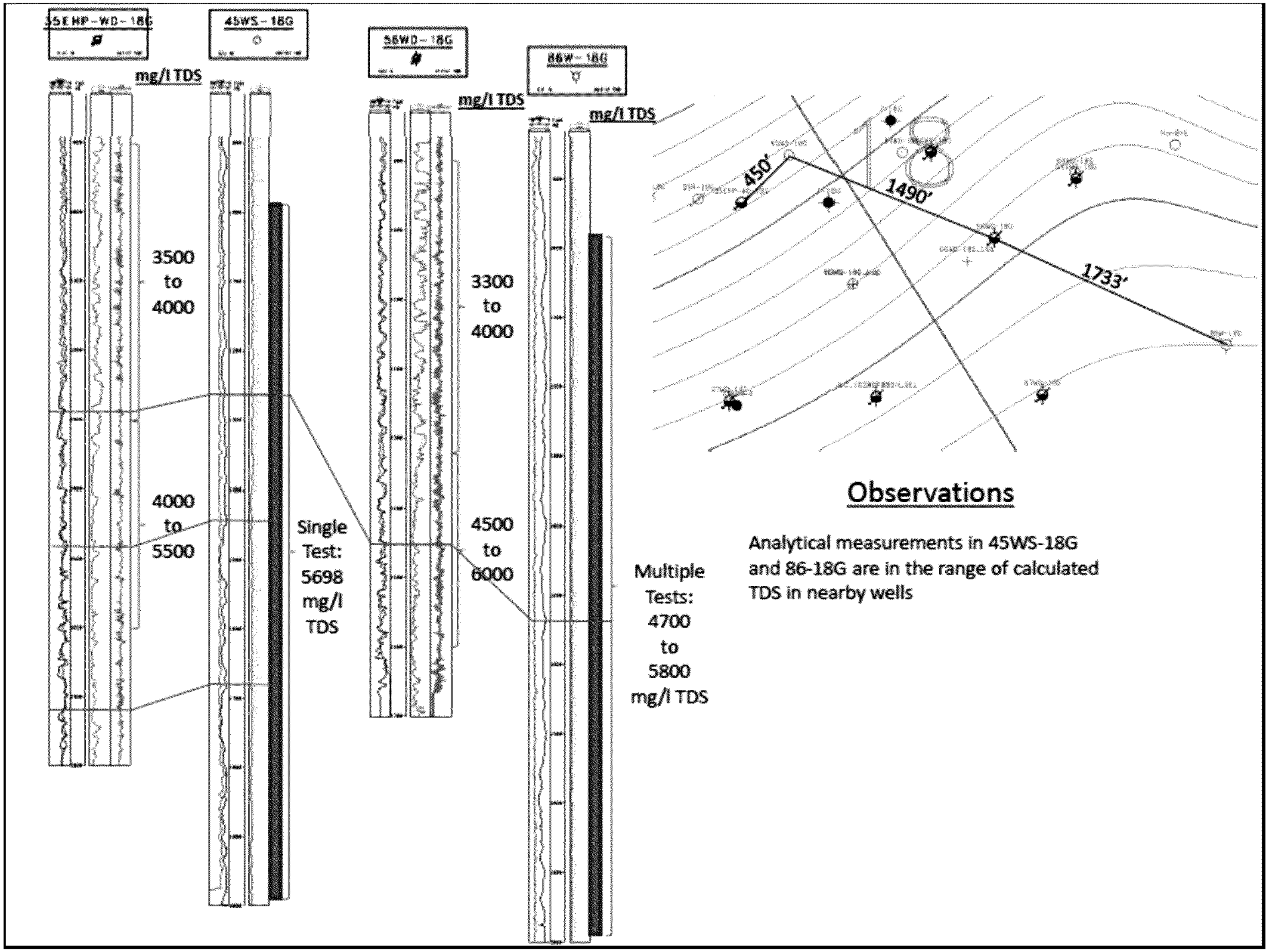
SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)

SAL_h = 10 ** ((3.562-(Log10(Rwahc-0.0123)))/.955)
= 10 ** ((3.562-(Log10(.269-0.0123)))/.955)
= 10 ** ((3.562+.5905)/.955)
= 22,300 ppm TDS

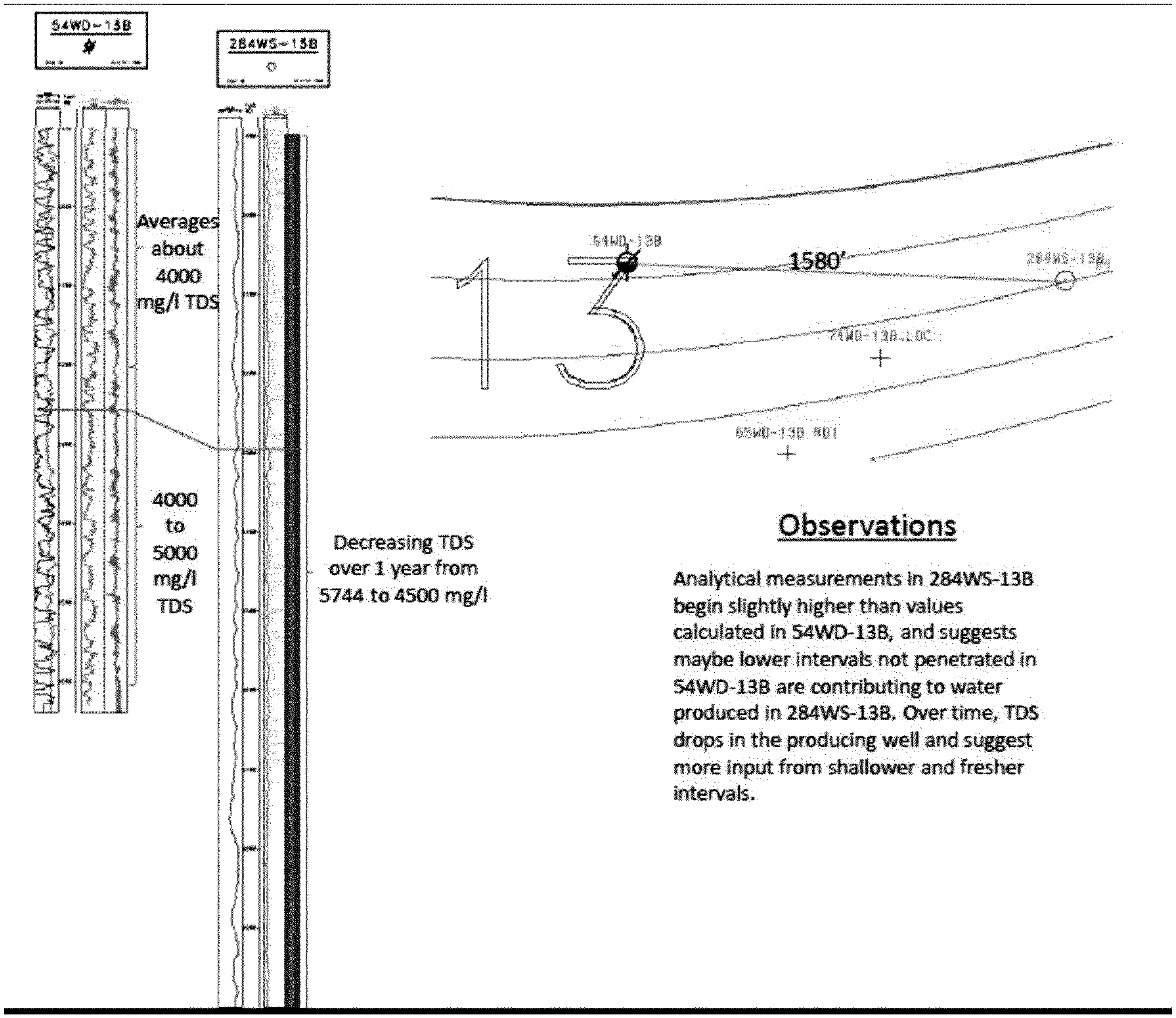
The nomograph is also used to estimate salinity from corrected apparent water resistivity and temperature. At the depth of 1020' (md) in well 86E-34R, the nomograph salinity value is between 23 and 24 kppm, or between 23,000 and 24,000 ppm.



Comparison of Measured and Calculated Salinities in the Lower Tulare in the 9G Area



Comparison of Measured and Calculated Salinities in the 18G Area



Comparison of Measured and Calculated Salinities in the 13B Area

Exhibit 31

Tulare Core Analyses

CONVENTIONAL CORE ANALYSES IN THE TULARE FORMATION

Bechtel UONPR #1 CH-27R					Williams Brothers Engineering Co. 36-30R				
Depth	Description	Horiz. Ka (md)	Vert. Ka (md)	Porosity (%)	Depth	Description	Vert. Ka (md)	Porosity (%)	Oil Sat. (%)
82.0	Sand			38.6	1,170.05	Sandstone	2,090.0	37.2	19.9
90.0	Sand		224.1		1,171.05	Sandstone	256.0	39.1	7.5
90.1	Sand		117.1		1,172.05	Sandstone	4,320.0	34.4	67.7
92.0	Sand	94.5		30.0	1,173.05	Sandstone	1,450.0	39.4	41.0
277.7	Sand		60.0		1,174.1	Sandstone	572.0	37.7	0.0
285.5	Sand			29.2	1,175.05	Sandstone	1,030.0	33.7	0.0
286.0	Sand	23.5		25.6	1,180.05	Sandstone	59.0	31.9	26.4
429.0	Sand		3,331.4	35.8	1,181.05	Conglomerate	2.0	12.3	4.9
430.0	Sand			44.2	1,182.1	Silty sandstone	724.0	31.1	44.3
430.1	Sand	3,114.6		41.5	1,183.05	Sandstone	3,080.0	24.2	33.7
435.6	Sand		3.7		1,184.05	Sandstone	3,200.0	35.8	46.8
463.5	Sand			42.4	1,185.1	Sandstone	1,980.0	38.7	48.6
490.0	Sand		3,544.5	37.7	1,186.2	Sandstone	1,840.0	39.3	56.1
530.7	Sand		2,402.4	40.7	1,187.25	Sandstone	2,040.0	40.4	53.1
531.0	Sand		3.7		1,188.8	Sandstone-siltstone	152.0	30.8	9.7
539.9	Sand	2,698.1		37.9	1,189.7	Silty sandstone	328.0	38.3	34.3
565.0	Sand		661.7		1,190.75	Silty sandstone	1,770.0	38.1	16.0
644.6	Sand		17.0		1,205.8	Sandstone	7.7	33.8	39.2
665.0	Sand	7,446.6		39.1		**Average:**	**1,383.4**	**34.2**	**30.5**
679.0	Sand		3,505.8	40.6		**Minimum:**	**2.0**	**12.3**	**0.0**
713.0	Sand			37.9		**Maximum:**	**4,320.0**	**40.4**	**67.7**
725.1	Sand		20.7						
773.0	Sand	4,092.7		40.8					
774.0	Sand		2,413.2	37.3					
837.0	Sand	2,511.2		37.7					
850.0	Sand		1,630.5						
856.0	Sand		489.2	35.9					
877.1	Sand	1,678.2		37.4					
899.0	Sand			33.3					
913.0	Sand	2,844.3		34.9					
918.0	Sand			38.3					
920.4	Sand		1,351.2						
974.5	Sand			33.4					
982.0	Sand			36.2					
988.0	Sand			37.0					
	Average:	**2,722.6**	**1,236.0**	**36.9**		**Average, Both Wells:**	**1,314.0**	**35.8**	
	Minimum:	**23.5**	**3.7**	**25.6**		**Minimum, Both Wells:**	**2.0**	**12.3**	
	Maximum:	**7,446.6**	**3,544.5**	**44.2**		**Maximum, Both Wells:**	**4,320.0**	**44.2**	

*** = Not used in analysis per notation on report.**

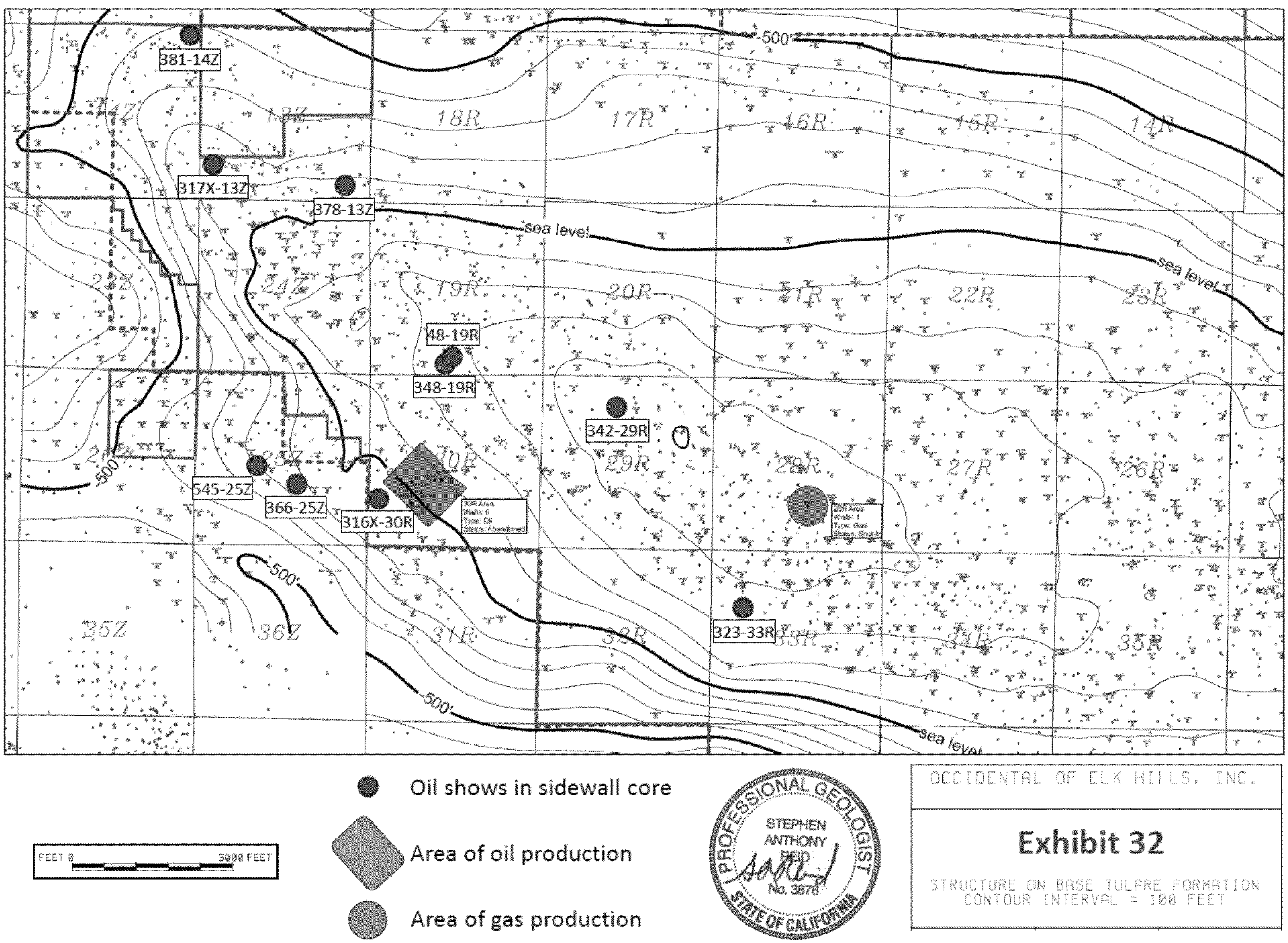
Bechtel UONPR #1 CH-27R				
Depth	**Description**	**Horiz. Ka (md)**	**Vert. Ka (md)**	**Porosity (%)**
266.0	Silt		1752.1*	36.6
279.5	Silt		<0.1	
559.8	Clay		<0.1	
605.0	Clay		<0.1	
694.1	Silt		<0.1	
750.0	Silt		0.1	
820.0	Clay		1.0	
893.3	Clay		<0.1	
938.0	Silt			26.8
940.8	Silt		1.0	
951.0	Silt			26.1
960.0	Claystone			24.9
963.0	Silt		<0.1	
969.0	Claystone			26.9
990.2	Silt		2.7*	
998.0	Claystone			34.7
998.0	Claystone	23.6		38.6
	Average:	**23.6**	**0.7**	**30.7**
	Minimum:	**23.6**	**<0.1**	**24.9**
	Maximum:	**23.6**	**1.0**	**38.6**
*** = Not used in analysis per notation on report.**				

Bergeson (1988) Core Analysis Summary					
Well	**Core Type**	**No. Samples**	**Permeability (md)**	**Porosity (%)**	**Oil Sat. (%)**
All Samples					
26E-30R	Sidewall	11	540	34.0	19.3
26E-30R	Core	33	253	37.3	21.2
36E-30R	Core	52	337	38.0	9.5
36E-30R	Core	50	654	38.4	17.7
36E-30R	Sidewall	13	1,111	32.3	31.2
Whole Curve Average:		159	**434**	**38.0**	**15.4**
	Minimum:		**253**	**32.3**	**9.5**
	Maximum:		**1,111**	**38.4**	**31.2**
Good Oil Sand Only					
26NE-30R	Core		309	38.2	33.1
36E-30R	Core		438	39.1	37.0
	Average:		**374**	**38.7**	**35.1**
	Minimum:		**309**	**38.2**	**33.1**
	Maximum:		**438**	**39.1**	**37.0**
NOTE: All cores cut with water-based mud.					

Exhibit 32

Maps of Producing Areas and Petroleum Occurrences in the Tulare Formation[24]

[24] All geologic work in this exhibit was prepared by Mr. Stephen A. Reid of OEHI, California-licensed Professional Geologist No. 3876.



Map of Producing Wells and Wells with Oil and Gas Shows in the Northwestern Area of the Elk Hills Field

Oil Shows in Well 316X-30R

GOODE CORE ANALYSIS SERVICE

Company: Bechtel Pet. Oper. Inc.
Well: UONPR #1 316X-30R
Field: Elk Hills
County,St: Kern CA

Location: Sec 30-30S-23E
Elevation: 1243' DF
Drlg Fluid:

File No.: 93489
API No.: 04-030-01882
Date: 1\13\1994
Core Type: Sidewall

Sample Number	Depth Feet	Rec Inches	Perm Ka md	Por %P.V.	Residual Sat. Percent Pore Oil	Residual Sat. Percent Pore Water	O/W Ratio	Total Liquid	Grain Den	Smpl Wt.	Mthd	Description
1	930.0	1.0	2608.8	34.1	0.0	76.0	0.00	76.0	2.66	15.3	(1)	Sd gy-ltan vf-fgr slslty no stn no flu
2	945.0	1.2	874.7	29.7	0.0	72.0	0.00	72.0	2.66	17.0	(1)	Sd gy vf-fgr slty cly calc no stn no flu
3	963.0	1.8	732.1	30.4	0.0	99.1	0.00	99.1	2.65	27.6	(1)	Sd gy vf-fgr slty no stn no flu
4	1135.0	2.0	586.4	32.5	0.0	98.2	0.00	98.2	2.63	28.8	(1)	Sd ltan-gy vf-fgr slty calc no stn no flu
5	1178.0	2.0	1979.1	26.7	0.0	85.9	0.00	85.9	2.65	29.2	(1)	Sd gy vf-vcgr slslty no stn no flu
6	1186.0	1.6	593.6	34.7	36.4	46.7	0.78	83.1	2.65	19.6	(1)	Sd brn vfgr slslty m-d stn dgld flu
7	1195.0	1.8	346.4	23.3	47.3	41.1	1.15	88.4	2.66	27.7	(1)	Sd brn vf-vcgr slty m-d stn vdyel flu
8	1200.0	2.0	394.0	34.7	57.1	42.4	1.35	99.6	2.69	31.2	(1)	Sd brn vfgr slty d stn vdgld flu
9	1420.0	2.0	150.4	31.9	0.0	98.6	0.00	98.6	2.72	32.5	(1)	Mdst gy vcly/abndt fos no stn no flu
10	1422.0	1.2	74.6	31.9	0.0	96.4	0.00	96.4	2.70	27.3	(1)	Same
11	2977.0	1.0	3909.7	30.9	2.7	44.1	0.06	46.8	2.76	20.0	(1)	Coca pyr lstrk stn dgld flu
12	3018.0	1.5	9.6	28.2	5.0	92.4	0.05	97.5	2.63	23.9	(1)	Sd tan-gy vf-fgr vslty cly lsp stn vdgld flu
13	3100.0	1.7	6.6	27.3	3.5	91.1	0.04	94.6	2.67	28.7	(1)	Sd dgy-tan vf-fgr vslty cly fos vlsp stn vdgld flu
14	5823.0	0.6	<1.0	41.2	2.8	70.6	0.04	73.4	2.39	6.2	(4)	Mdst brn frac no stn vdgld flu
15	5841.0	0.5	<1.0	37.7	1.5	91.0	0.02	92.5	2.42	7.2	(4)	Mdst dbrn frac no stn no flu
16	5930.0	1.3	<1.0	31.4	1.6	92.2	0.02	93.8	2.51	17.9	(4)	Same
17	5941.0	1.0	<1.0	40.2	0.5	87.1	0.01	87.6	2.39	6.5	(4)	Same
18	6072.0	1.0	<1.0	43.0	4.7	81.2	0.06	85.9	2.43	4.4	(4)	Same
19	6123.0	0.7	<5.0	35.8	4.1	66.0	0.06	70.1	2.37	10.2	(4)	Mdst brn shly/ slt lam no stn
20	6182.0	1.3	<1.0	34.7	6.0	84.2	0.07	90.3	2.55	14.2	(4)	Mdst dbrn frac no stn no flu

For Mthd Definition See Procedures Page

PROFESSIONAL GEOLOGIST
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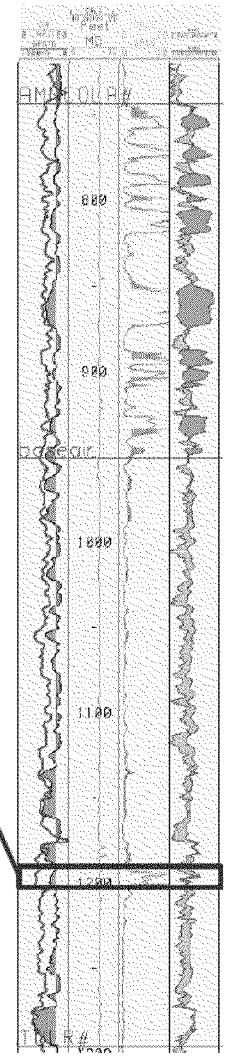


Tulare oil shows in the 316X-0R

Oil Shows in Well 342-29R

TO ______ 194__

FROM ______

SUBJECT: WELL 42-29R FILE: 10/14/45

HOMCO SIDEWALL SAMPLES

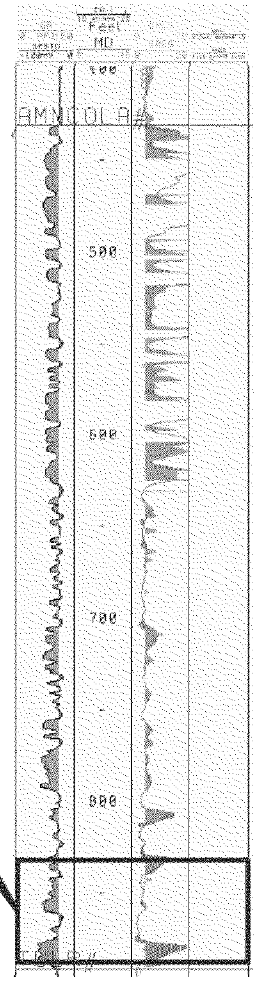
DEPTH	RECOVERY	DESCRIPTION
806	6"	Sand, med. grnd, clayey, friable, gray-green.
810	6"	Siltst. gray, clayey
832	6"	Siltst. gray, patches sand grey, med grnd
836	6"	Siltst. gray, friable, faint petrol. odor.
851	5"	Siltst. gray, clayey patches faint petrol. odor?
857	6"	Siltst. gray, well sorted
860	6"	Clyst., silty, grey. faint petrol. odor?
879	4"	Sand, brn, irregulary sorted, fair petrol. odor.
883	6"	Sand, fine grained, brn., fair petrol. odor
888	6"	Siltst., gray, patches clyst with carbonaceous material
946	3"	Siltst., grey, well sorted.
948	6"	Siltst. gray, irregular bedding.
953	6"	Siltst, gray very clayey
1002	6"	Siltst. gray, clayey.
1102	4"	Siltst. grey, laminae clyst, grey, carb. material
1106	6"	" " " " " " "
1119	6"	Siltst., grey, well sorted.
1122	6"	Siltst. grey, clayey.
1167	6"	Siltst, grey, laminae clyst, grey.

BK10532694
O.EHI

mcl

TOUR REPORT

WHEN REPLY IS REQUIRED, FORWARD ORIGINAL AND ONE COPY.



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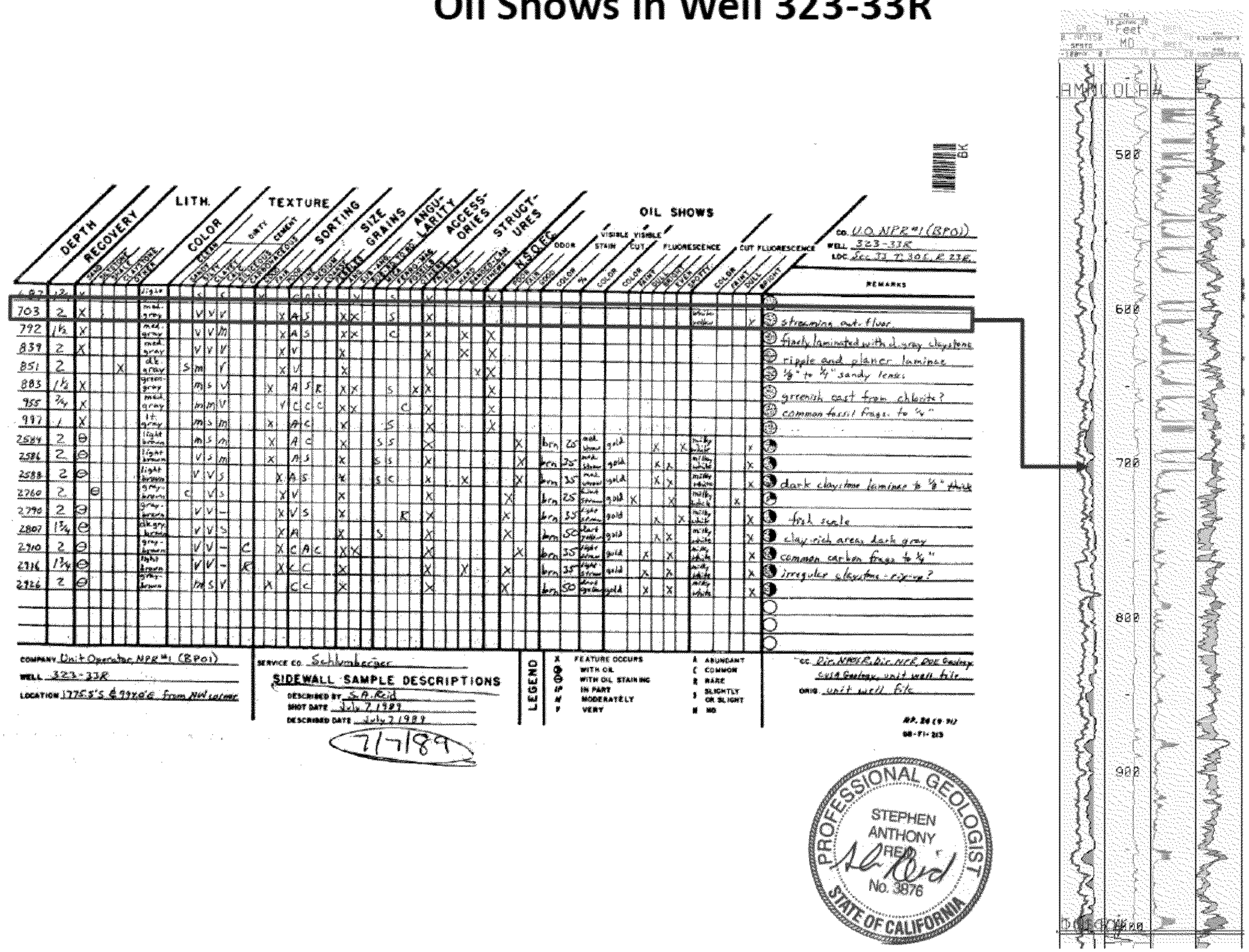
Oil Shows in Well 323-33R



Oil Shows in Well 348-19R

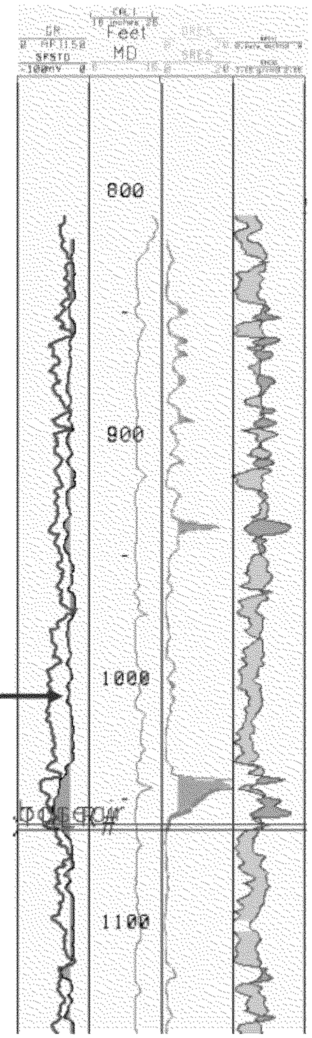
S ide Core Analysis Service

Page No. ______

P. O. BOX 9291
BAKERSFIELD, CALIFORNIA 93309

Company	WILLIAMS BROTHERS ENGINEERING COMPANY UONPR#1	Formation		File	80223
Well	348-19"R"	Core Type	SIDEWALL	Date Report	14 MAY 80
Field	ELK HILLS	Drilling Fluid	WATER BASE	Analysts	BG
County	KERN State CALIF. Elev.	Location	SEC.19- 30S- 23E		

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE OIL	RESIDUAL SATURATION PER CENT PORE TOTAL WATER	O/W	SMPL WT.	SAMPLE DESCRIPTION AND REMARKS
1	993	62	35.4	0.0	82.1	.00	16	SD; tan, vfgr, v slty, no stn, no flu.
2	994	18	36.6	0.0	86.1	.00	14	Same/hvy sh lams.
3	1004	4.9	34.4	0.0	91.9	.00	12	Same
4	1010	230	35.7	39.6	49.5	.80	14	SD; brn, vfgr, v slty, dk stn, dull gold flu.
5	1122	0.5	34.3	0.0	92.4	.00	14	SH; dk gry, no stn, no flu.
6	1131	180	30.1	0.0	77.6	.00	15	SD; tan, fgr, v slty, no stn, no flu.
7	1138	16	25.1	0.0	95.0	.00	11	Same, v shy.
8	2612	30	22.9	0.0	87.9	.00	14	Same/shells.
9	2618	11	22.4	0.0	86.7	.00	15	SD; tan, [illegible] slty, v shy, no stn, no flu.
10	2650	21	30.0	0.0	86.3	.00	15	SD; tan, fgr, v slty, shy, no stn, no flu.
11	2652	43	26.4	0.0	87.2	.00	14	Same
12	2704	29	26.6	0.0	89.2	.00	16	Same, lam.



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Oil Shows in Well 48-19R

Telephone 2-7252

wall file

H[illegible]NKOHL LABORAT[illegible]IES

ANALYSES OF OIL, WATERS, SOILS, OIL [illegible]

P. O. Box 1673

1016 18th STREET
BAKERSFIELD, CALIFORNIA

October 11, 1945

Laboratory No. 18171 to 18173

Sample Oilwell Cores *Marked* Well 48-19-R at depths shown.

Received October 10, 1945

Submitted by U.O. - N.P.R. #1
Standard Oil Co. of Calif.,OPR.
Box 77, Tupman, Calif. * * * * * * * *

BK10713441

OIL CORE ANALYSES

Description of Sands:

940' : Fine grained, well consolidated, silty, blackish-gray, clayey sand; no petroleum odor, cut, or fluorescence.

1005' : Medium to fine grained, firm, silty, oil sand.

1038' : Fine grained, clayey, blue-gray, silty sand; sample very badly contaminated with mud.

	940'	1005'	1038'	
cc. Oil per 100 cc. Sand	0.0	12.0	--	Sample from 1038' was too small and badly intermixed with mud to make a saturation determination
Oil Saturation, per cent	0.0	30.8	--	
cc. Water per 100 cc. Sand	33.9	26.0	--	
Water Saturation, per cent	98.7	66.7	--	
Oil - Water Ratio	Zero	0.462	--	
Gravity of Oil, °API	--	15-17	--	
Recommended Perforations, Mesh	D N P	100	--	
Salt Content, Grains per Gallon	106	225	--	
Effective Porosity, per cent	34.35	39.03	41.13	
Permeability in Millidarcys				
Parallel to Bedding Plane	14.7	88.9	16.4	
Perpendicular to Bedding Plane	14.0	49.8	15.1	

NOTE: These samples were somewhat weathered prior to submitting to laboratory for tests.
DNP: = Do not perforate.
The sample from 1005' can be classified as a commercial oil sand; the comparatively high water saturation is due to drilling fluid infiltration, as indicated by carbonate tests on the distilled water extract of the cooked sands.

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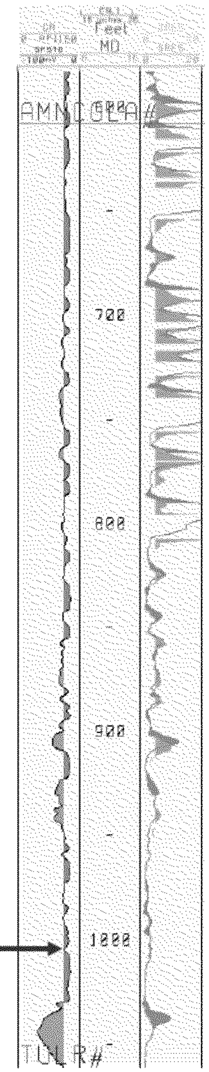

Oil Shows in Well 381-14Z

P. O. BOX 9291
BAKERSFIELD, CALIFORNIA 93309

WILLIAMS BROTHERS ENGINEERING

Company: COMPANY UDNPR#1 | Formation: | File: 82224
Well: 381-14"Z" | Core Type: SIDEWALL | Date Report: 12 MAY 82
Field: ELK HILLS | Drilling Fluid: WATER BASE | Analysts: BG
County: KERN | State: CALIF. | Elev. | Location: SEC.14- 30S- 22E

SAMPLE NUMBER	DEPTH FEET	PERMEABILITY MILLIDARCYS	POROSITY PER CENT	RESIDUAL SATURATION PER CENT PORE		O/W	SMPL WT.	SAMPLE DESCRIPTION AND REMARKS
				OIL	TOTAL WATER			
1	[illegible]	0.2	30.0	0.0	98.2	.00	11	Cly; dk gry, no stn, no flu
2	825	0.1	38.5	17.1	80.5	.21	10	SH; dk gry, frac/shells, no stn, no flu.
3	834	0.3	29.7	0.0	99.4	.00	11	Cly; dk gry/fn sd incls, no stn, no flu.
4	836	160	25.9	0.0	85.3	.00	16	SD; gry, fgr, v slty, lmy, no stn, no flu.
5	842	2680	30.7	0.0	81.5	.00	8	SD; gry, f-vcgr, no stn, no flu.
6	844	21	37.8	0.0	78.9	.00	14	SD; gry, vfgr, v slty, lmy/sh incls, no stn, no flu.
7	854	8.8	36.5	0.0	80.2	.00	13	Same
8	890	32	26.7	0.0	60.8	.00	12	Same
9	904	19	38.8	0.0	87.6	.00	11	SD; gry, vfgr, v slty, lmy, no stn, no flu.
10	920	0.7	35.3	0.0	92.0	.00	12	Cly; gry, no stn, no flu.
11	930	54	40.4	0.0	75.2	.00	12	SD; gry, vfgr, v slty, lmy/sh incls, no stn, no flu.
12	950	83	36.3	4.3	72.6	.06	10	SD; tan, f-cgr, slty/cly incls, lt stn, dull yell sp flu.
13	960	190	34.6	0.0	79.2	.00	15	SD; gry, fgr, v slty, no stn, no flu.
14	1018	3.9	31.6	0.0	90.0	.00	8	SH; gry, sdy, no stn, no flu.
15	1020	24	33.7	0.0	86.1	.00	13	SD; gry, vfgr, v slty, lmy/sh wisps, no stn, no flu.
16	1075	91	33.1	0.0	79.1	.00	12	Same
17	1095	34	35.8	0.0	85.2	.00	10	Same
18	1098	9.0	41.3	0.0	81.5	.00	8	Same
19	1136	270	36.3	0.0	84.8	.00	16	SD; gry, fgr, v slty, lmy, no stn, no flu.
20	1157	26	39.9	0.0	73.9	.00	13	Same, v shy.
21	1158	790	32.5	0.0	57.7	.00	16	SD; gry, f-vcgr, slty, no st no flu.
22	1199	1640	29.9	0.0	81.2	.00	16	Same
23	1201	1290	35.3	0.0	86.5	.00	12	Same
24	1206	17	27.5	0.0	92.2	.00	14	SD; gry, vfgr, v slty, lmy, no stn, no flu
25	1222	2170	32.0	0.0	80.8	.00	14	SD; gry, f-vcgr, no stn, no flu.
26	1228	1670	31.9	0.0	55.0	.00	8	Same
27	1230	820	35.5	0.0	67.5	.00	12	SD; gry, fgr, v slty, no str no flu.

...opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential...

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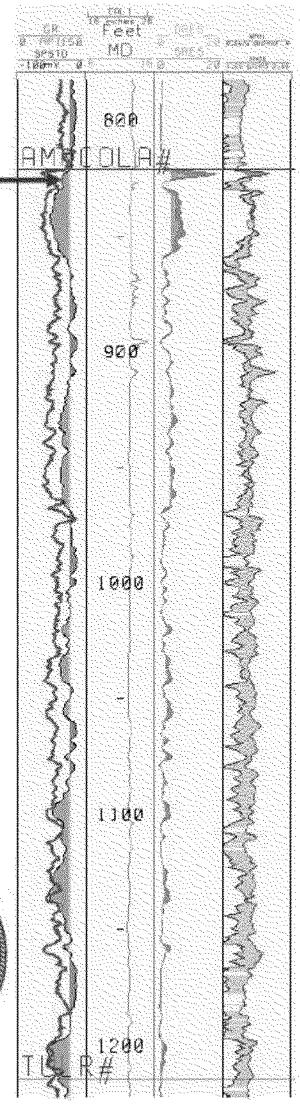
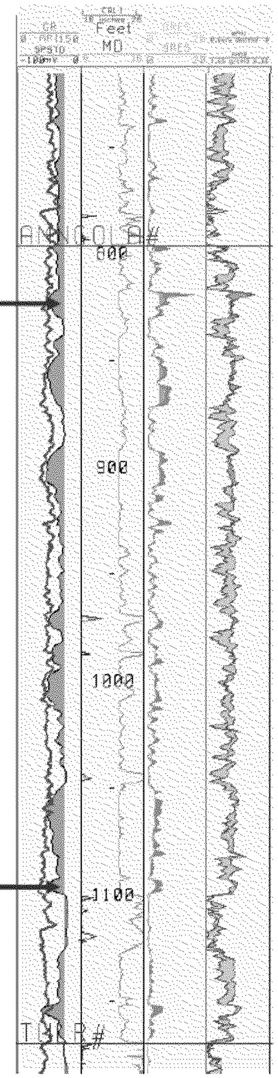


Oil Shows in Well 317X-13Z

ample umber	Depth Feet	Permeability Millidarcys	Porosity Per Cent	Residual Sat Percent Pore Oil	Total Water	O/W Ratio	Total Liquid	Sample Description and Remarks
1	824.0	837.00	32.0	0.6	83.7	0.01	84.3	GR DEN 2.63 Sd gy vf-fgr lt strk stn dull gold flu
2	855.0	732.00	28.6	0.0	87.1	0.00	87.1	GR DEN 2.68 Sd gy vf-mgr / sh lam no stn no flu
3	865.0	113.00	37.7	0.0	93.5	0.00	93.5	GR DEN 2.61 Clyst gy / vlg vf-cgr sd lam no stn no fl u
4	905.0	3063.00	34.8	0.0	83.6	0.00	83.6	GR DEN 2.62 Sd gy f-mgr no stn no flu
5	1060.0	447.00	31.9	0.0	95.3	0.00	95.3	GR DEN 2.64 Sd gy vf-fgr vslty / cgr lam no stn no fl u
6	1096.0	149.00	26.9	0.8	96.7	0.01	97.5	GR DEN 2.59 Sd gy vf-cgr vslty / lg cly lam lt strk s tn dull gold flu
7	1154.0	176.00	30.5	0.0	79.1	0.00	79.1	GR DEN 2.69 Sd gy vf-fgr slty cly no stn no flu
8	1275.0	152.00	32.3	0.0	95.0	0.00	95.0	GR DEN 2.66 Same
9	2302.0	228.00	27.8	0.0	93.6	0.00	93.6	GR DEN 2.64 Sd gy vfgr slty / cly lam no stn no flu
10	2455.0	70.00	35.8	1.4	97.0	0.01	98.4	GR DEN 2.61 Sd tan vfgr vslty vcly lt sp stn dull gol d flu
11	2470.0	42.00	29.8	8.1	89.0	0.09	97.1	GR DEN 2.58 Sd lt brn vf-fgr vslty vcly m sp stn gold flu
12	2534.0	58.00	31.5	10.3	79.6	0.13	89.9	GR DEN 2.55 Sd tan vfgr slty fos / cly lam m stn gold flu
13	2554.0	125.00	30.9	2.8	83.1	0.03	85.9	GR DEN 2.59 Sd gy-tan vf-cgr vslty cly lt strk stn du ll gold flu
14	2606.0	39.00	30.6	2.6	90.3	0.03	92.9	GR DEN 2.59 Sd gy-tan vf-mgr vslty vcly lt strk stn d ull gold flu
15	2621.0	7.90	30.0	0.0	71.1	0.00	71.1	GR DEN 2.58 Sd gy-tan vf-mgr slty lt strk stn gold fl u
16	2675.0	26.00	31.7	0.0	97.5	0.00	97.5	GR DEN 2.59 S[illegible] vslty vcly no stn no flu
17	2875.0	14.00	29.8	0.0	92.3	0.00	92.3	GR DEN 2.63 Sltst gy cly / sd lam no stn no flu
18	2940.0	28.00	30.2	0.0	96.1	0.00	96.1	GR DEN 2.63 Sd gy vfgr vslty cly no stn no flu

omment : Dean Stark Analysis



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STATE OF CALIFORNIA

Oil Shows in Well 378-13Z

Goode Core Analysis Service

P. O. BOX 9291
BAKERSFIELD, CALIFORNIA 93309

8-11-88

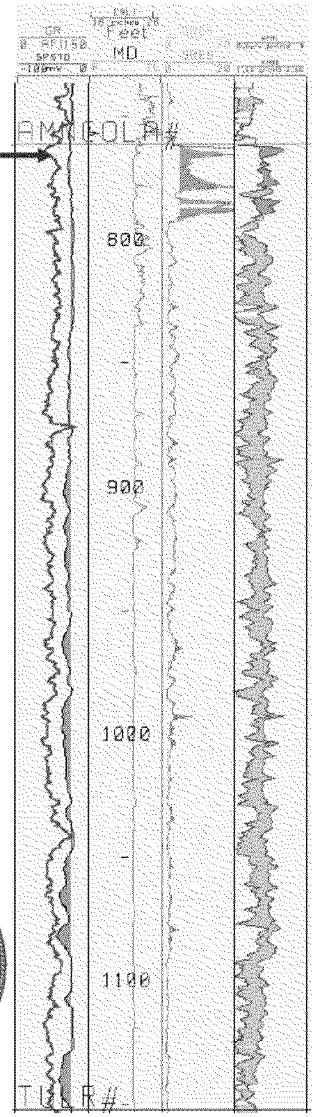
Page No. 1

WILLIAMS BROTHERS
Company: ENGINEERING CO. UONPR#1 — Formation: — File: 79138
Well: NO. 378-13 "Z" — Core Type: SIDEWALL — Date Report: 8 MAY 79
Field: ELK HILLS — Drilling Fluid: WATER BASE — Analysts: BG
County: KERN — State: CAL. — Elev.: — Location: SEC. 13- 30S- 22E

Sample Number	Depth Feet	Permeability Millidarcys	Porosity Per Cent	Residual Saturation Per Cent Pore: Oil	Residual Saturation Per Cent Pore: Total Water	O/W	SMPL WT.	Sample Description and Remarks
1	725	3.8	28.5	0.0	97.7	.00	15	Cly; gry/fn tan vfgr sd lam, v lt stn, yell flu on sand.
2	765	76	32.8	0.4	88.9	.01	14	SD; tan, vf-fgr, slty/shy sd lams, lt stn, dull yell flu.
3	787	820	31.4	0.0	77.1	.00	15	SD; gry, fgr, slty/fn sh lams, no stn.
4	964	1030	33.1	0.0	86.7	.00	14	SD; lt tan, fgr, no stn, no flu.
5	1032	110	33.0	0.0	90.3	.00	14	SD; gry, vfgr, v slty/fn sh lams, no stn, no flu.
6	1752	9.1	36.1	0.0	89.0	.00	14	SD; tan, vfgr, v shy/fnly lam, no stn, no flu.
7	1753	4.6	36.3	0.0	82.4	.00	14	Same
8	2209	7.9	35.4	0.5	87.2	.01	12	SD; gry, vfgr, v slty, v shy/shells, no stn, no flu.
9	2294	23	31.6	23.4	52.7	.44	10	SD; tan, fgr, pbly, shy, lmy/diatomite incls, & shells, lt stn, yell sp flu.
10	2390	26	34.0	1.2	87.4	.01	15	SD; tan, vfgr, v slty, shy, lt stn, dull gold flu.
11	2431	47	24.2	1.4	80.0	.02	17	SD; lt tan, fgr, slty, shy, lmy, v lt stn, dull yell flu.
12	2432	410	34.7	5.8	64.9	.09	18	SD; tan, fgr, v slty/fn cly incls, lt stn, dull yell flu.
13	2487	87	25.9	11.9	74.2	.16	18	SD; tan, vfgr, v slty, cly/shells, lt stn, dull yell flu.
14	2488	43	26.0	11.9	60.6	.20	14	Same, lmy.

These analyses, opinions or interpretations are based on observations and materials supplied by the client to whom, and for whose exclusive and confidential use, this report is made. The interpretations or opinions expressed represent the best judgement of Goode Core Analysis Service (all errors and omissions excepted); but Goode Core Analysis Service and employees, assume no responsibility and make no warranty or representations, as to the productivity, proper operations, or profitableness of any oil, gas or other mineral well or sand in connection with which such report is used or relied upon.

PROFESSIONAL GEOLOGIST
STEPHEN ANTHONY REID
No. 3876
STATE OF CALIFORNIA



Oil Shows in Well 366-25Z

CORE LABORATORIES, INC.
Petroleum Reservoir Engineering
DALLAS, TEXAS

PAGE 1

CHEVRON U.S.A. INC.
25Z' 366-25Z
ASPHALTO FIELD
KERN COUNTY,CA.

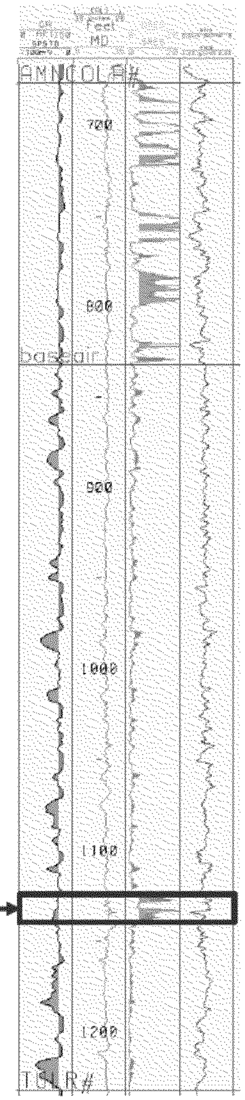
DATE : 14-AUG-84
FORMATION :
DRLG. FLUID: WB
LOCATION : SEC.25-T30S/R22E

FILE NO : 13443
LABORATORY: BAKERSFIELD
ANALYSTS : DLK,BC
ELEVAION : 1140' DF

SIDEWALL CORE ANALYSIS

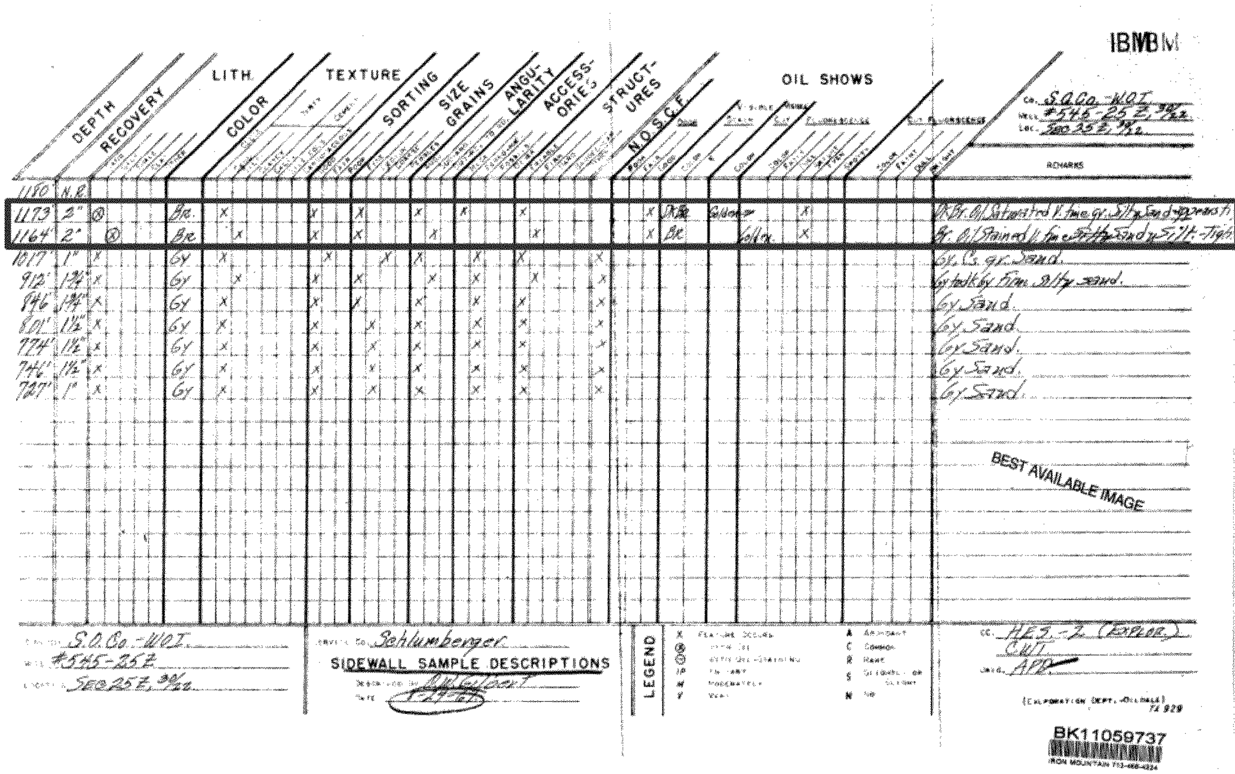
EC IN	DEPTH	PERM MD(*)	POR %	OIL% PORE	WTR% PORE	O/W RATIO	SAMPLE WEIGHT	API OIL	DESCRIPTION
1.0	1127.0	1750.	26.9	46.6	35.3	1.32	8.99	14	SD;BRN,VF-MGR,SSLTY,DSTN,DGLD FLU
1.5	1136.0	6.2	35.8	28.3	52.4	0.54	10.36		SLT;LT BRN,VFGR SDY,MSTN,DGLD FLU
1.3	1260.0	200.	34.0	19.7	55.1	0.36	8.26		SD;GY-BRN,VF-FGR,SLTY,SCALC,MSTR STN,GLD
1.3	1263.0	150.	32.8	17.5	47.4	0.37	8.23		SAME
	2733.0								NO SAMPLE
1.3	2736.0	90.	26.6	0.0	74.4	0.00	10.40		SD;GY,VF-MGR,SLTY,CLY STR,NO STN,NO FLU
1.8	2744.0	30.	30.8	0.6	69.8	0.01	11.12		SD;TN-GY,VF-MGR,VSLTY,VCLY,FOS,LSP STN,GL
1.4	2746.0	0.2	33.2	0.0	83.5	0.00	4.85		CLY;GY,FOS,LSTR STN,DGLD FLU
1.5	2782.0	20.	31.9	16.4	57.6	0.28	5.57	24	SD;BRN,VFGR,VSLTY,CLY LAMS,MSTR STN,DGLD
1.5	2784.0	2.3	36.3	1.6	82.2	0.02	10.05		SH;TN-GY,VFGR SDY LAMS,SLT STR,LSTR STN,G
1.6	2870.0	15.	33.6	0.8	85.9	0.01	14.73		SD;TN-GY,VFGR,VSLTY,CLY,SCALC,DGLD FLU
1.4	2874.0	8.6	38.4	0.5	78.5	0.01	9.42		SAME
1.3	2889.0	6.0	26.7	1.0	70.2	0.01	7.94		SAME/VDGLD FLU
1.1	2891.0	10.	29.0	1.4	71.9	0.02	9.90		SAME
1.5	2920.0	5.0	41.4	0.4	88.9	0.00	10.87		SAME
3	2922.0	3.5	37.1	0.5	80.4	0.01	10.57		SAME/VCLY
1.6	2937.0	25.	37.5	0.0	89.7	0.00	11.88		SD;GY,VFGR,VSLTY,VCLY,NO STN,NO FLU
1.3	2944.0	14.	32.2	0.0	80.2	0.00	12.32		SAME/GRAN
1.3	2946.0	30.	35.1	5.3	59.9	0.09	8.39		SD;TN-GY,VF-FGR,CLY LAMS,MSP STN,DGLD FLU
1.3	2947.0	45.	31.5	1.1	82.3	0.01	12.01		SAME
1.5	2956.0	60.	30.4	2.3	80.5	0.03	5.81		SAME/SCLY
1.4	2993.0	4.3	35.1	0.5	84.8	0.01	10.96		SAME/HVY CLY LAM

(*) PERMEABILITY VALUES FOR PERCUSSION TYPE SIDEWALL CORES DETERMINED EMPIRICALLY.



PROFESSIONAL GEOLOGIST
STEPHEN ANTHONY REID
No. 3876
STATE OF CALIFORNIA

Oil Shows in Well 545-25Z



Depth	Recovery	Color	Fluorescence	Remarks
1180	N.R.			
1173	2"	Br.	Golden	Dk Br. Oil Saturated V. fine gr. Silty Sand
1164	2"	Br.	Yellow	Br. Oil Stained V. fine Sandy Silt - Tight
1017	1"	Gy		Gy. C. gr. Sand.
912	1¼"	Gy		Gy tight Fine silty sand.
846	1¼"	Gy		Gy Sand.
801	1½"	Gy		Gy Sand.
774	1½"	Gy		Gy Sand.
746	1½"	Gy		Gy Sand.
727	1"	Gy		Gy Sand.

Co. S.O.Co.-WOT.
Well #545-25Z
Location Sec 25Z, 30/22

Service Co. Schlumberger
SIDEWALL SAMPLE DESCRIPTIONS

BEST AVAILABLE IMAGE

BK11059737

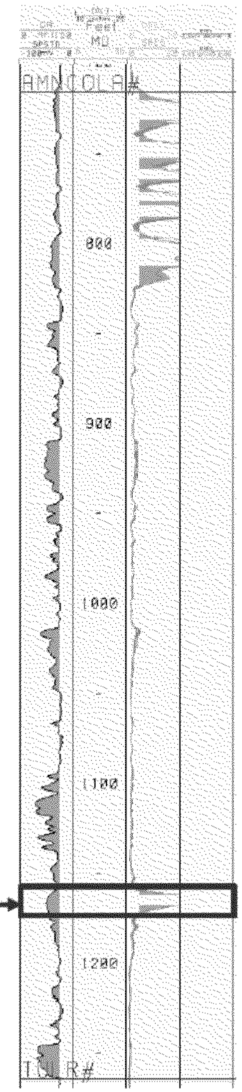
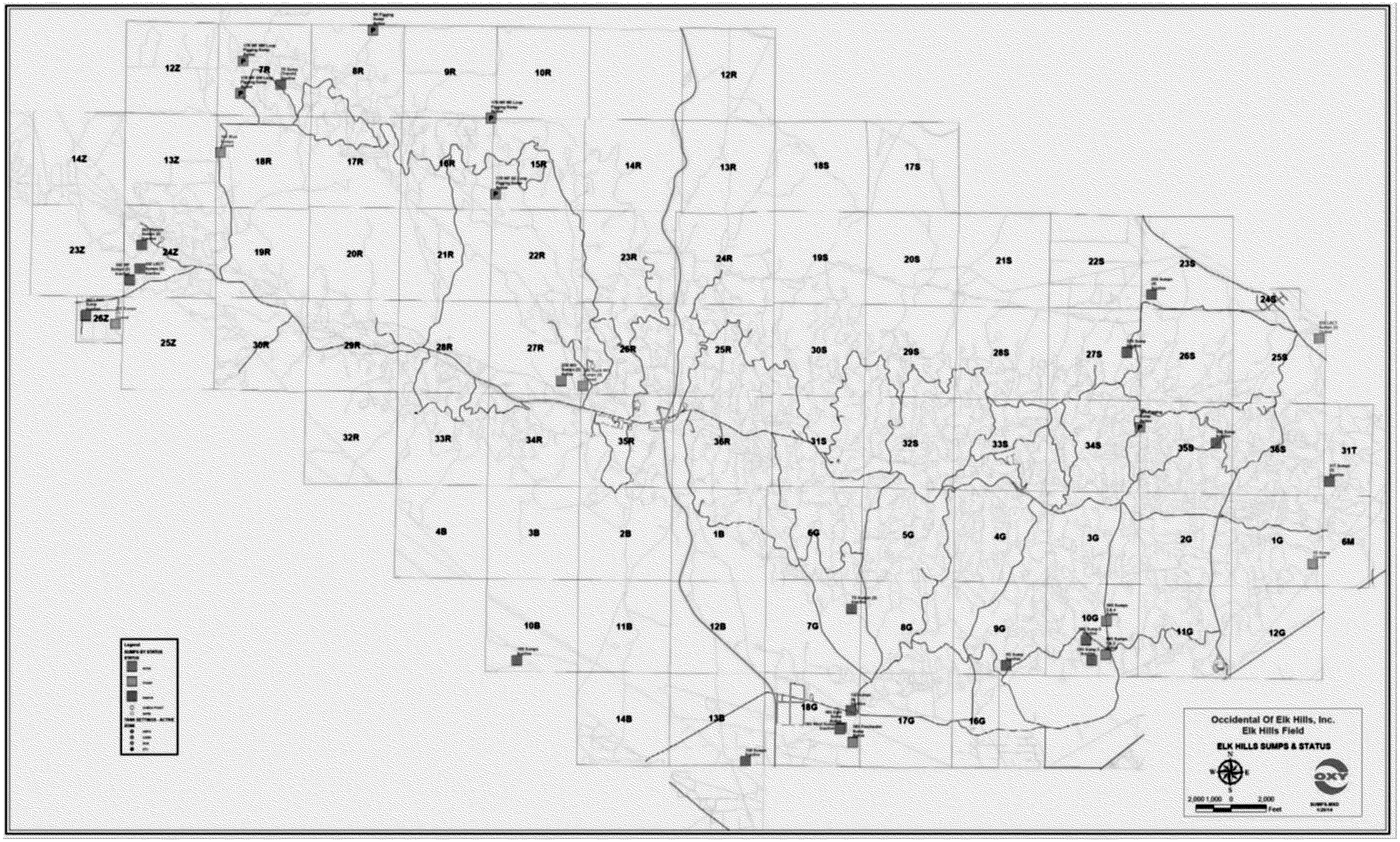


Exhibit 33

Map of Sumps within the Area of Review



Locations and types of sumps in the Elk Hills field. See Table 8 of this document for the current status of these sumps.

Exhibit 34

Surface Ownership Map

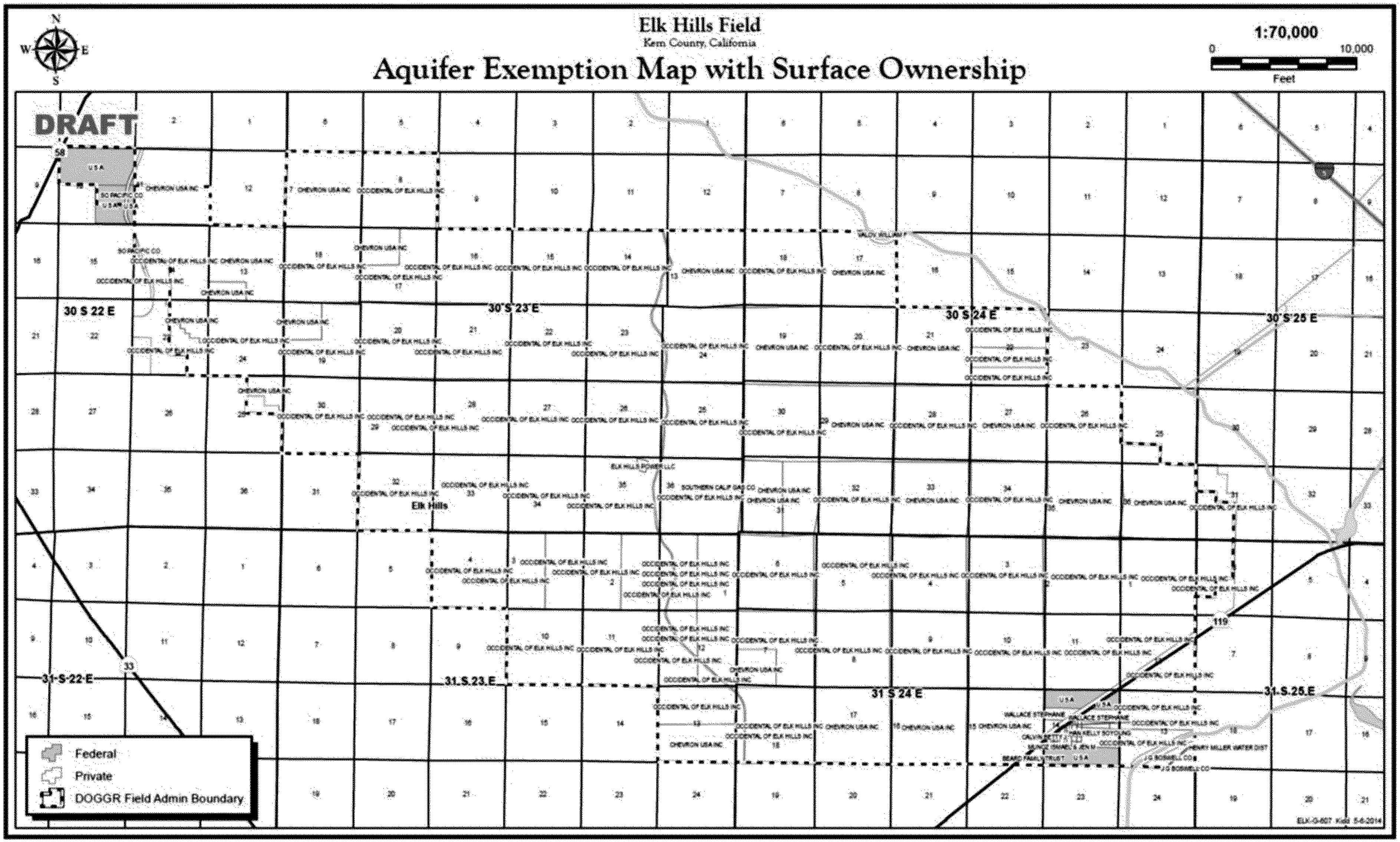
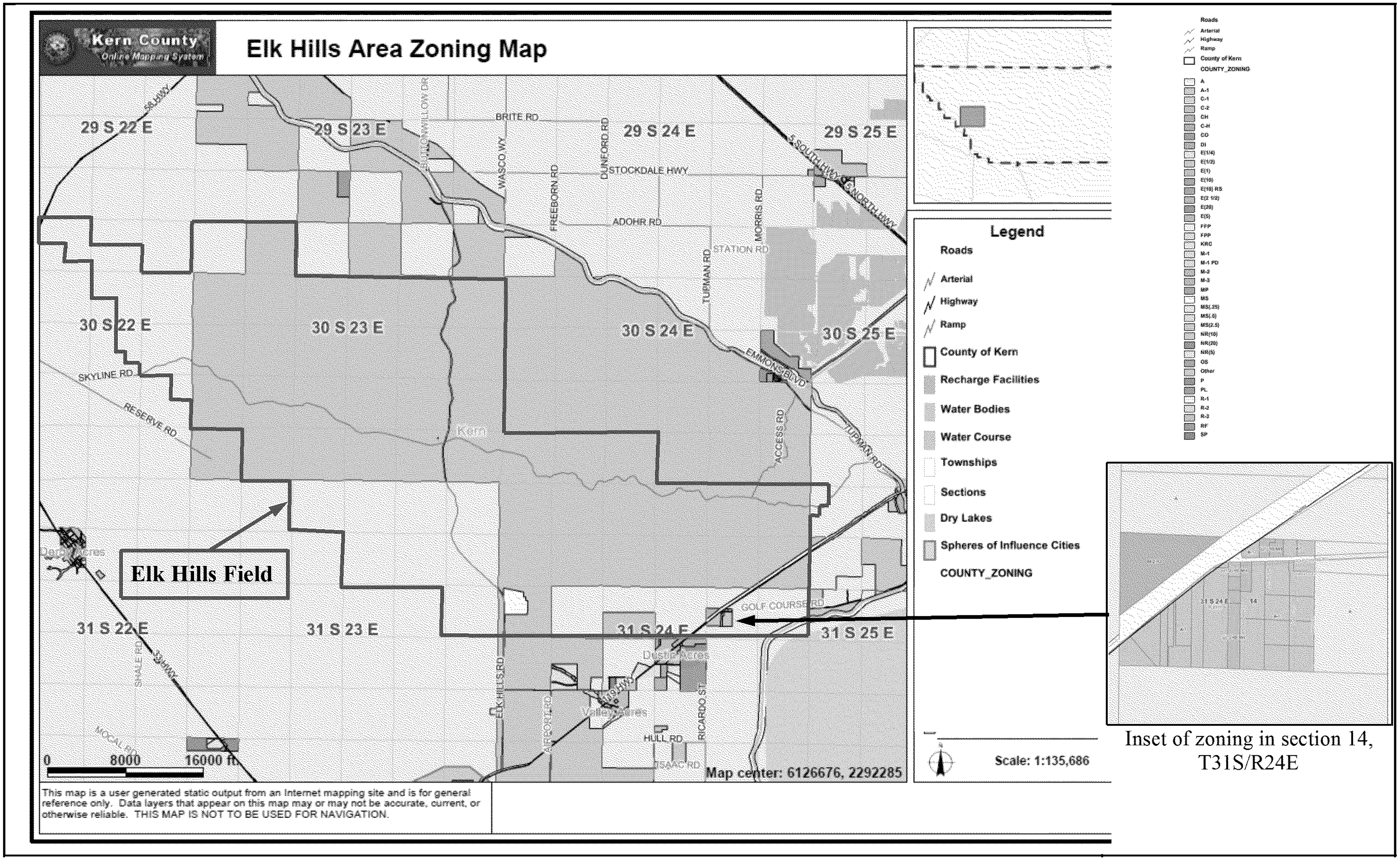

Elk Hills Field
Kern County, California
Aquifer Exemption Map with Surface Ownership
1:70,000
0
10,000
Feet
DRAFT
30 S 22 E
30 S 23 E
30 S 24 E
30 S 25 E
31 S 22 E
31 S 23 E
31 S 24 E
31 S 25 E
Elk Hills
Federal
Private
DOGGR Field Admin Boundary

Exhibit 35

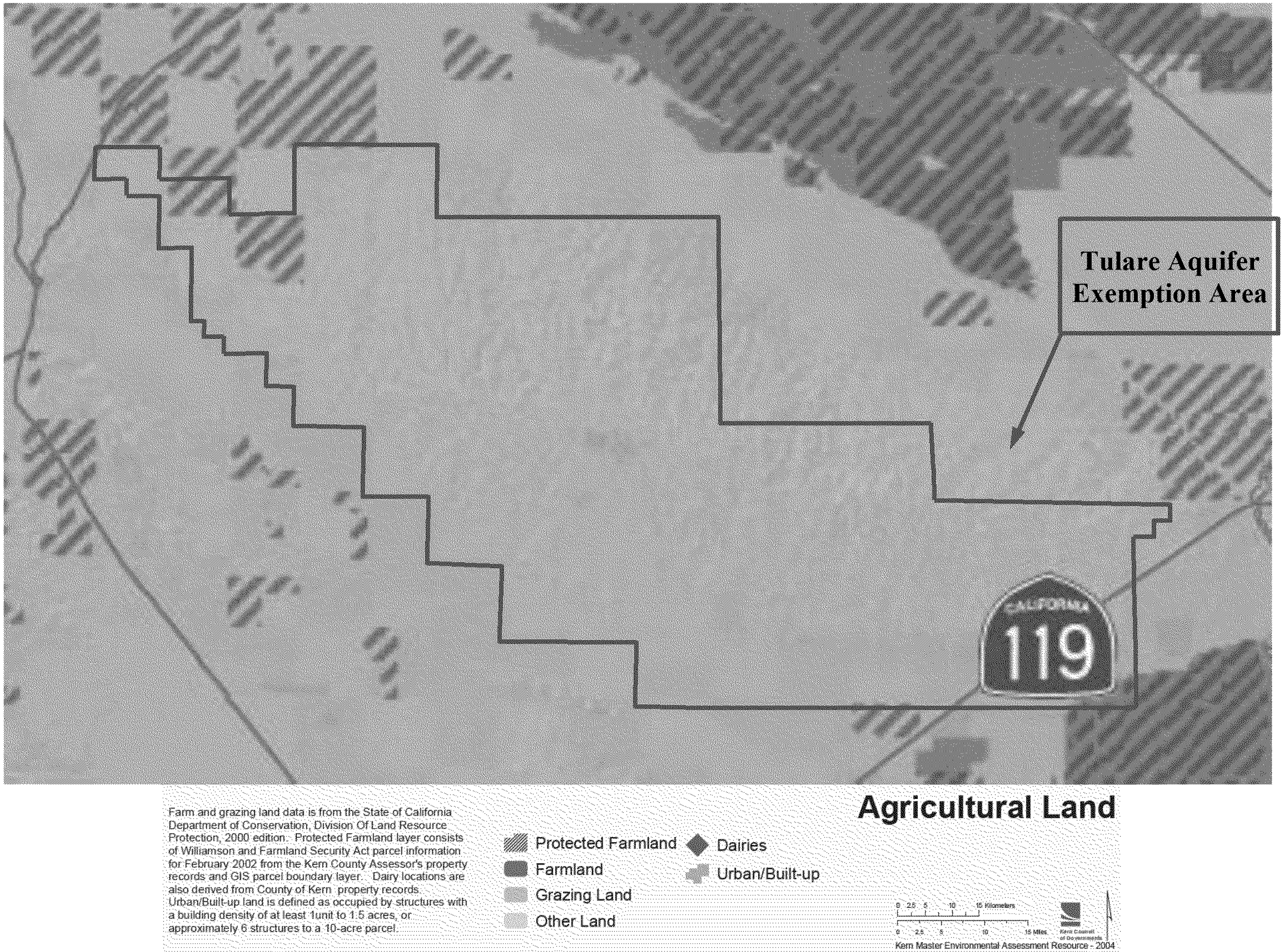
Zoning Map



(Source: Kern County Online Mapping System, 2014)

Exhibit 36

Agricultural Land Use Map



Agricultural Land Use Map for a Portion of the Elk Hills field *(Source: Kern County Council of Governments, 2006)*

Exhibit 37

GIS Map

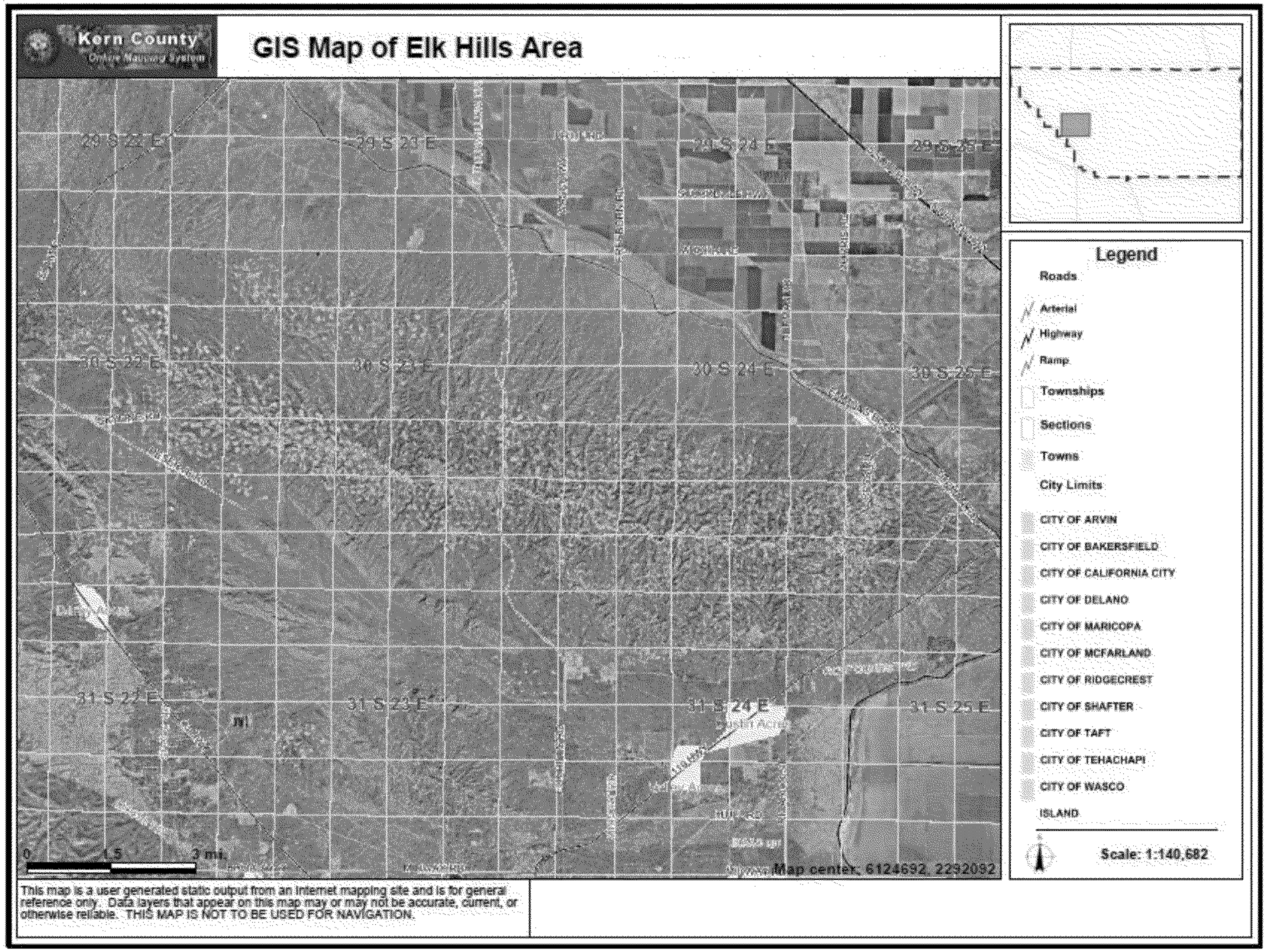
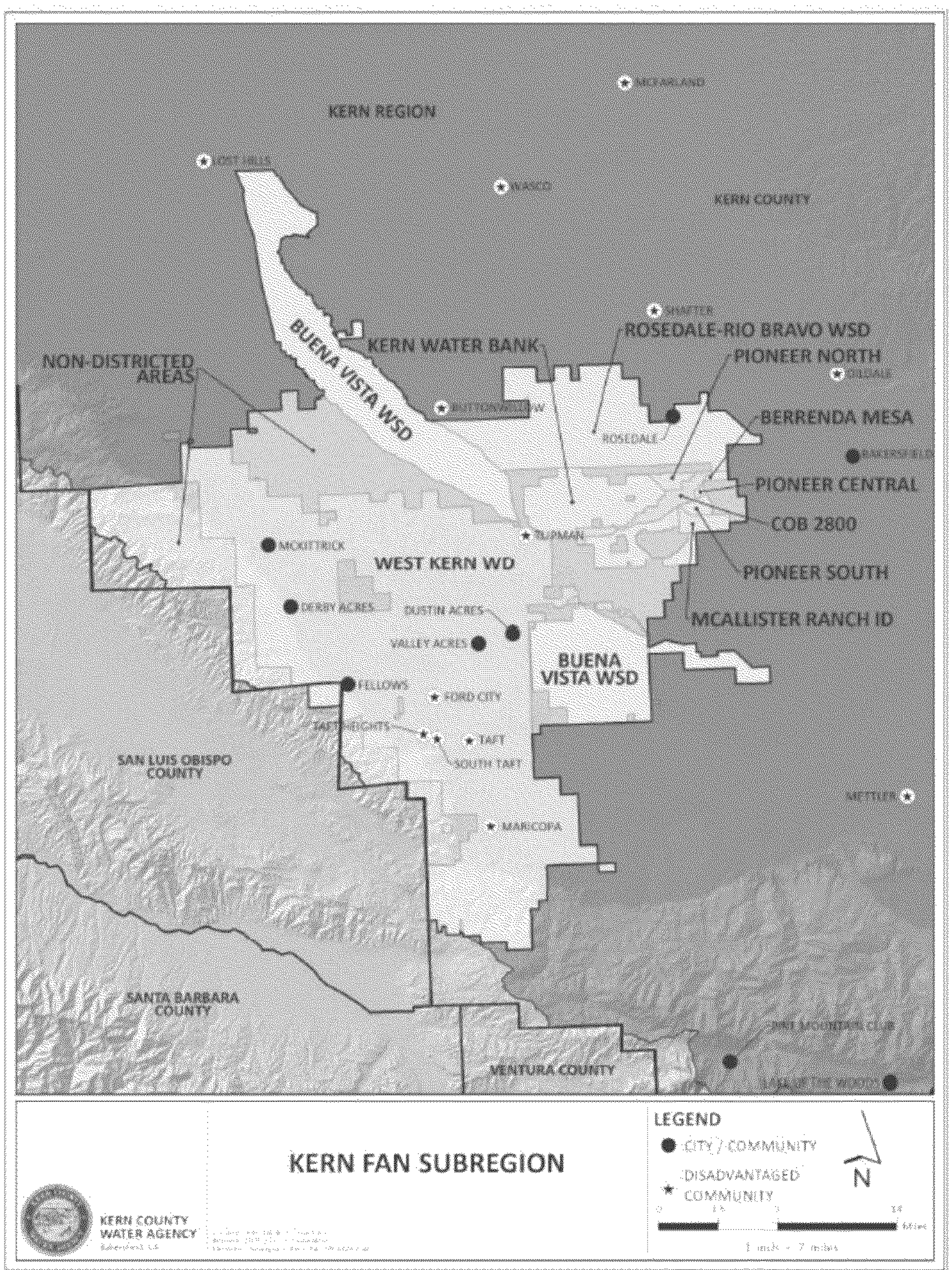

Kern County
Online Mapping System
GIS Map of Elk Hills Area
29 S 22 E
29 S 23 E
29 S 24 E
29 S 25 E
30 S 22 E
30 S 23 E
30 S 24 E
30 S 25 E
31 S 22 E
31 S 23 E
31 S 24 E
31 S 25 E
0 1.5 3 mi.
Map center: 6124692, 2292092
Legend
Roads
Arterial
Highway
Ramp
Townships
Sections
Towns
City Limits
CITY OF ARVIN
CITY OF BAKERSFIELD
CITY OF CALIFORNIA CITY
CITY OF DELANO
CITY OF MARICOPA
CITY OF MCFARLAND
CITY OF RIDGECREST
CITY OF SHAFTER
CITY OF TAFT
CITY OF TEHACHAPI
CITY OF WASCO
ISLAND
Scale: 1:140,682
This map is a user generated static output from an Internet mapping site and is for general reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable. THIS MAP IS NOT TO BE USED FOR NAVIGATION.

Exhibit 38

Map of Water Districts within the Area of Review



Kennedy/Jenks Consultants

Tulare Lake Basin Portion of Kern County , IRWMP – Final Update

Kern Fan Subregion

K/J 0889044*00

November 2011

Map of Water District in the Aquifer Exemption Area

Note: The Elk Hills field lies entirely within the West Kern Water District service area.

Exhibit 39

Stantec Borehole 356XH-26R

2.0 FINDINGS

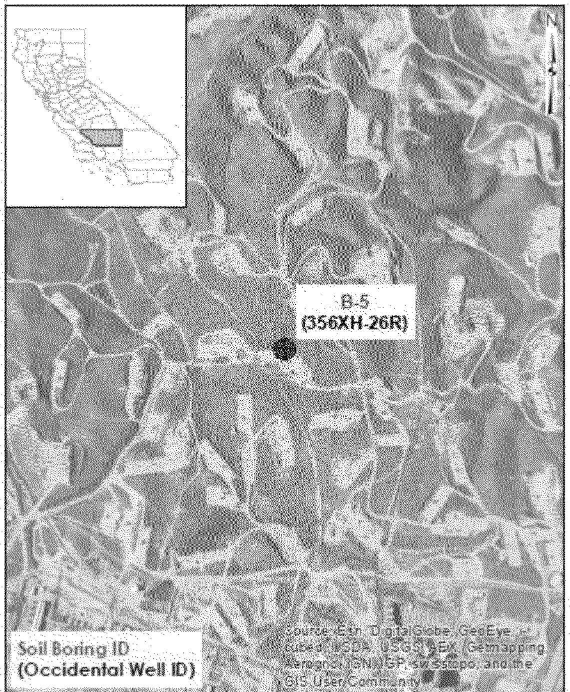
On April 1, 2, 3, and 4, 2014, Stantec oversaw National in the advancement of soil boring B-5. Utility clearance was conducted by USA Dig alert and OEHI prior to drilling activities. Boring B-5 was completed approximately 75 feet northeast of Well 356XH-26R. The borehole is located on a graded pad situated within the hills. Outcrops of the Tulare Formation (weathered siltstone and silty sandstone) were observed to the north the cut slopes of the graded pad.

The borehole was advanced using an ARCH drill rig equipped with an 8 1/2-inch diameter drill bit to 320 feet bgs. Outer casing (9 5/8-inch outer diameter) was driven to approximately 320 feet bgs. The final split-barrel sampler was driven to a depth of approximately 321.5 feet bgs.

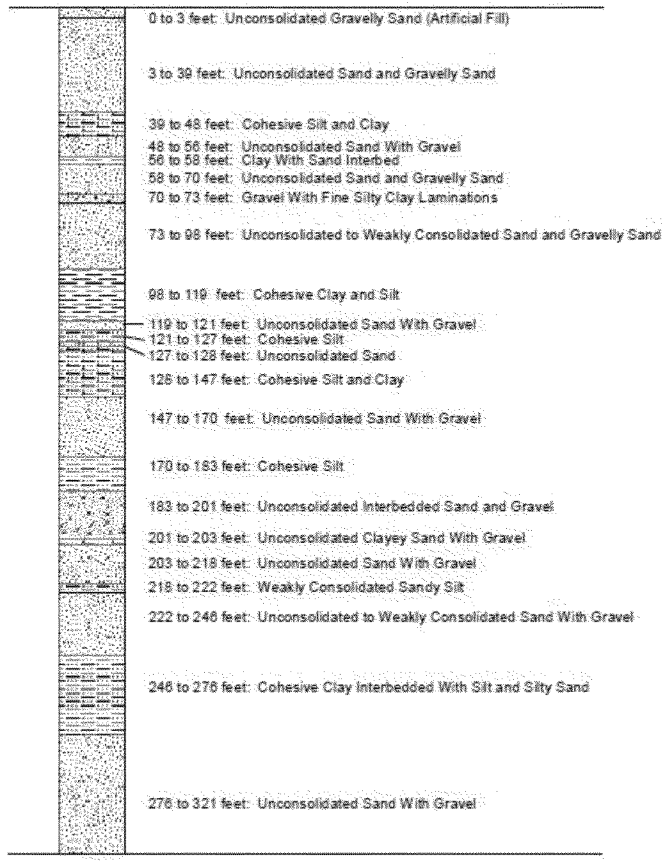
Samples were collected at ten-foot intervals using an 18-inch length split-barrel sampler and from select intervals in the drill cutting to the terminal depth of 320 feet bgs. All samples were logged, labeled with the boring identification, depth, date, and time prior to photo documentation.

Visible outcrops of the Tulare Formation were noted in the cut slopes proximal to the soil boring. Samples collected from B-5 were within the Tulare Formation for the entire boring with the exception of artificial fill from grading of the pad in the upper approximate three feet.

Two perched water bearing zones were encountered during advancement of B-5. First encountered water was in a gravelly sand zone at approximately 120 feet bgs perched on a silt layer at 121 feet bgs. Drilling was stopped and the boring gauged; water was measured at approximately 108 feet bgs, suggesting confined conditions. A water sample was collected and analyzed in the field for total dissolved solids with a result of 2,016 parts per million (ppm). No groundwater was observed from 121 to 239 feet bgs. Water was encountered again from approximately 240 to 246 feet bgs within a sand layer perched above a clay layer. The boring was gauged but due to sloughing of the native material at depth only minimal water was encountered. A water sample was collected and analyzed in the field for total dissolved solids with a result of 12,020 ppm. The 240 to 246 foot zone water sample was noted to contain a heavier brown liquid that settled to the bottom of the sample bottle and may possibly be drilling mud. The borehole was completed to a total depth of 320 feet bgs with no additional water encountered. After the boring was completed to total depth, a water-level meter was lowered to the bottom of the boring to evaluate the presence of water in the borehole; no water was detected. Both water samples were submitted to BC Laboratories Inc. in Bakersfield, California for Geochemical analyses; results are pending. Boring and Photo Logs can be found as Appendix A and B, respectively.



*The location shown is for the Soil Boring, which is, located within approximately 75-feet northeast of the associated Occidental Well (as labeled).



290 Conejo Ridge Ave Thousand Oaks, CA 91361 Phone 805.230.1266 Fax 805.230.1277 www.stantec.com	For: Occidental of Elk Hills, Inc. 28590 Highway 119 Tupman, California 93276		**Soil Boring B-5 Summary Lithologic Log**		Figure: **1**
	Job Number: 185850241	Drawn By: Michael Bartosek	Checked By: StephAnnie Roberts	Approved By: Gareth Roberts	Date: 04/01/2014

GEOGRAPHIC INFORMATION SYSTEMS (GIS)

Exhibit 40

Evaluation of Economic Feasibility of Treating McKittrick Area Groundwater for Use as Drinking Water

DRAFT

EVALUATION OF ECONOMIC FEASIBILITY OF TREATING McKITTRICK AREA GROUNDWATER FOR USE AS DRINKING WATER

submitted to:

La Paloma Generating Company
McKittrick, CA

prepared by:

Kennedy/Jenks Consultants
2151 Michelson Drive, Suite 100
Irvine, California 92612-1311

March 2002

Kennedy/Jenks Consultants
Engineers & Scientists

TABLE OF CONTENTS

DRAFT

List of Tables and Figure

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EXECUTIVE SUMMARY

La Paloma Generating Company, LLC, currently is completing the installation and startup of the La Paloma Generating Plant (Plant) a 1,048-megawatt (MW) natural gas-fired, combined-cycle power plant in McKittrick, CA. The current plant design includes the underground injection of the wastewater generated from cooling tower blowdown and reject water from zero discharge (membrane) units from the Plant into an injection well. Discharge of Plant wastewater into the aquifer is possible only if EPA classifies the aquifer as Class III water (groundwater not a source of drinking water).

United States Environmental Protection Agency (EPA) has developed a draft final guidance document entitled "Guidelines for Ground-Water Classification under the EPA Ground-Water Agency" [USEPA, 1986] to categorize groundwater into various classes based on their uses. This evaluation documents the technical and economic feasibility of treating McKittrick area groundwater for use as a drinking water source using the general procedure described for designating groundwater as Class III (groundwater not a source of drinking water) by the EPA document. A brief summary of EPA's guidelines for defining Class III waters is given below.

- Contamination of the groundwater cannot be treated by treatment technologies identified by the document as "methods reasonable employed in Public-Water Systems" or "methods known to be used in limited number of cases".
- The total annual system cost per average household (i.e. per household cost to develop, treat and deliver the water) is more than 0.4% of median annual income, and
- The annual increase in water rate for the average household due to the cost of the groundwater treatment is $300/year (1986 cost) or 100% of the current rate.

Evaluation of groundwater quality at the Plant injection well site indicates that the groundwater contains a high concentration of total dissolved solids (TDS) (6,100 milligrams per liter [mg/l]). In addition, this water has high concentrations of boron (21 mg/l), sulfate (1,200 mg/l), chloride (1,600 mg/l) and hardness (1,100 mg/l). Based on EPA's guidelines for applicable technologies and preliminary evaluation, detailed cost estimates were performed for treating McKittrick area groundwater using Reverse Osmosis (RO) technology. Two design flow rates (165,000 gpd and 2.85 gpd) were selected for evaluation.
mgd

The economic evaluation indicated that the cost of treated water per acre-foot is about $34,500 for the smaller system and $5,800 for the larger system. This is about 10 to 70 times more than the current potable water cost ($500/AF) in the McKittrick area. In addition, the cost of developing groundwater system per household in the project area will be about 75% of the mean annual income for the smaller system and 11% of the annual income for the larger system, which are higher than the threshold limit recommended by EPA (0.4% of annual income). Furthermore, the increase in annual water rate per household due to the groundwater treatment will be about $17,500 for the smaller treatment system and $2,700 for the larger system, which are greater than the limits specified by the EPA document ($455). Based on these evaluations, the groundwater in the McKittrick area meets the criteria prescribed in the EPA document for groundwater classification to be designated as Class III (groundwater not a source of drinking water) water.

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SECTION 1. INTRODUCTION

Background

La Paloma Generating Company, LLC, currently is completing the installation and startup of the La Paloma Generating Plant (Plant) a 1,048-megawatt (MW) natural gas-fired, combined-cycle power plant. The Plant, located in McKittrick, California, is designed with four 262 MW units that can be operated to meet the demand for electricity by the electrical power grid. The current design includes the underground injection of the wastewater generated from cooling tower blowdown and reject water from zero discharge (membrane) units from the Plant into an injection well. The U. S. Environmental Protection Agency (EPA) has identified the aquifer where the injection well is located as a potential underground source of drinking water (USDW) [40 CFR]. This classification of the aquifer precludes its use for injection of the wastewater as a Class I injection well. Discharge of Plant wastewater into the aquifer is possible only if EPA classifies the aquifer as Class III water (groundwater not a source of drinking water).

Evaluation of groundwater quality at the Plant injection well site indicates that the groundwater contains a high concentration of total dissolved solids (TDS) (6,100 milligrams per liter [mg/l]) [Zalco Laboratories, Inc., 2001], and meets the criteria set by the California State Water Resource Control Board, Resolution No. 88-63 adopted 19 May 1988, to be exempted from designated as a "source of drinking water" (greater than 3,000 mg/l). In addition, this water has high concentrations of boron, alkalinity and hardness. These characteristics can render the treatment cost of the water as uneconomical for use as a drinking water source.

This evaluation documents the technical and economic feasibility of treating McKittrick area groundwater for use as a drinking water source. The EPA has developed a draft final guidance document entitled "Guidelines for Ground-Water Classification under the EPA Ground-Water Agency" [USEPA, 1986] to categorize groundwater into various classes based on their uses. The general procedure described for designating groundwater as Class III (groundwater not a source of drinking water) is used as the basis for this evaluation. A brief summary of EPA's guidelines for defining Class III waters is given below.

Summary of EPA Guidelines for Ground-Water Classification

EPA's draft final guidance document entitled "Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy" describes the procedures and information needs for classifying the nation's groundwaters. Accordingly, groundwaters are grouped into the following three classes:

- Class I – Special groundwater
- Class II – Groundwater currently and potentially a source of drinking water, and
- Class III – Groundwater not a source of drinking water

According to this document, groundwater can be designated as Class III water if there is:

- "Contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that can not be cleaned up using <u>treatment methods reasonably employed in public water-supply systems</u> (<u>or economically treated</u>)."

As indicated in the above statement by EPA, the technical and economic criteria for classification of McKittrick area groundwater will be evaluated in this study. The technical and economic basis for classification of Class III water provided by the EPA document is briefly summarized below:

Technical basis for classification of groundwater as Class III water

According to the EPA document, a groundwater may be classified as Class III if no reasonable technology is available for treatment of the contamination. The document has provided the list of technologies reasonably used by public systems and those not used by public systems, to facilitate classification based on available technologies. Table 1 presents the list of technologies identified by EPA.

Table 1: List of treatment technologies used and those not used in public water systems

Methods reasonably employed in Public-Water Systems	Methods known to be used in limited number of cases	Methods not in use by Public Water Systems
Aeration, air stripping, carbon adsorption, chemical precipitation, chlorination, floatation, fluoridation and granular media filtration	Desalination (***reverse osmosis [RO]***, ultrafiltration and electrodialysis), ion-exchange and ozonation	***Distillation*** and wet air oxidation

The McKittrick area groundwater is contaminated with high concentrations of TDS (6,100 mg/l). None of the technologies listed as "Methods reasonably employed in Public Water Systems" can be used for removal of the levels of TDS found in McKittrick groundwater to be used as drinking water. Among the methods listed as "Methods known to be used in limited number of cases" Desalination using RO technology may be used for removing TDS from brackish/saline waters. However, this technology is not known to be used in Kern County/Central Coast region for treating brackish/saline waters containing high levels of TDS as found in McKittrick groundwater. Distillation processes that are sometimes used in desalination of seawater are recognized as "Methods not in use by Public Water Systems".

Economic basis for classification of groundwater as Class III water

The EPA document also provides guidelines for defining Class III waters, based on economic viability. The guidelines for determining the economic viability of using the groundwater for drinking water involve the following steps:

1. Determine the size of the hypothetical user population
2. Determine the mean annual income per household
3. Estimate the cost of water treatment processes (cost to treat the water)
3. Estimate the cost of the water supply system (cost to develop, treat and deliver the water)
4. Classify groundwater as Class III, if

- The total annual system cost per average household (i.e. per household cost to develop, treat and deliver the water) is more than 0.4% of median annual income, and
- The annual increase in water rate for the average household due to the cost of the groundwater treatment is $300/year (1986 cost) or 100% of the current rate.

Objective

The objective of this study is to determine whether the McKittrick groundwater meets EPA's criteria for classifying this water as Class III water based on economic evaluation. EPA's "Guidelines for Ground-Water Classification under the EPA Ground-Water Agency" is used as the basis for the evaluation. The following specific tasks were performed:

- The water quality of McKittrick area groundwater was evaluated and potential drinking water quality issues identified.
- The cost of treating the McKittrick area groundwater to meet the regulatory requirements were evaluated and compared with current potable water cost in the project area.
- The per household share of the annual water treatment system cost was evaluated. Potential exceedance of potable water cost threshold limit (0.4% of annual income) was determined.
- The impact of the new treatment system in the increase in average household water rates was evaluated.

Report Outline

This report is divided into four sections. Section 1 (this Section) provides the background of the project, general approach for the economic evaluation and the objective of the study. Section 2 presents the water quality analyses of the McKittrick area groundwater and presents the results from a preliminary evaluation of the treatment technologies for the groundwater. Section 3 presents the detailed cost evaluation for the selected treatment technology and presents the results from economic feasibility analyses per the EPA guidelines document. Section 4 presents the conclusions of the analyses.

SECTION 2. WATER QUALITY EVALUATION AND PRELIMINARY SCREENING OF TREATMENT TECHNOLOGIES

Evaluation of the McKittrick Area Water Quality and Treatment Goals

A sample of groundwater from the La Paloma injection well site was collected in December 2001 and analyzed for various constituents. Table 2 shows some water quality characteristics of the groundwater and the California DHS regulatory levels (maximum contaminant level [MCLs] and action levels) for these compounds in drinking water. As shown in the table, the groundwater consists of hard water (1,100 mg/l as $CaCO_3$) with a high TDS concentration (6,100 mg/l). The TDS concentration qualifies the water to be exempted from being classified as a "source of drinking water" by the California State Water Resource Control Board, Resolution No. 88-63. In addition, the water contains boron, chloride, and sulfate at concentrations higher than the current MCLs or action levels.

The goals of this evaluation are to evaluate treatment cost in order to:

- Identify a treatment process to effectively reduce the concentrations of TDS, chloride, sulfate and boron from the McKittrick area groundwater in order to meet drinking water regulatory limits,
- Evaluate treatment costs for the identified process.

Since historical water quality data for the aquifer is not available, a $\pm$ 25% of the concentration of the constituents shown in Table 2 was considered as the range of constituent concentrations for treatment design and cost evaluation.

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Table 2: Water quality characteristics of McKittrick groundwater and DHS regulatory levels for potable water

Constituent	Unit	Injection well water quality	Primary MCL	Secondary MCL	Action Level	Exceedance of MCLs or AL
Calcium	mg/l	160				
Magnesium	mg/l	180				
Sodium	mg/l	1,300				
Potassium	mg/l	23				
Iron (Dissolved)	mg/l	0.56		0.3		Yes
Alkalinity (Hydroxide)	mg/l	0				
Alkalinity (Carbonate)	mg/l	0				
Alkalinity (Bicarbonate)	mg/l	670				
Chloride	mg/l	1,600		250		Yes
Sulfate	mg/l	1,200		250		Yes
Sulfide	mg/l	<0.5				
Boron	mg/l	21			1	Yes
Total Dissolved Solids	mg/l	6,100		500		Yes
Electrical Conductivity	µmhos/cm	9,160		900		Yes
Calculated Hardness	mg/l	1,100				
Total Alkalinity, $CaCO_3$	mg/l	550				
Antimony	mg/l	<0.2	0.006			NK
Arsenic	µg/l	4.5	10			
Barium	mg/l	<0.1	1			
Beryllium	mg/l	<0.01	0.004			NK
Cadmium	mg/l	<0.01	0.005			NK
Chromium	mg/l	<0.05	0.05			
Cobalt	mg/l	<0.1				

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Constituent	Unit	Injection well water quality	Primary MCL	Secondary MCL	Action Level	Exceedance of MCLs or AL
Copper	mg/l	0.33		1.0	1.3	
Lead	mg/l	<0.05			0.015	
Mercury	mg/l	<0.002	0.002			
Molybdenum	mg/l	0.18				
Nickel	mg/l	<0.05	0.1			
Selenium	mg/l	<0.05	0.05			
Silver	mg/l	<0.02		0.1		
Thallium	mg/l	<0.5	0.002			NK
Vanadium	mg/l	<0.1				
Zinc	mg/l	0.12				

NK – Not known. The reporting limits used for analyses are higher than the MCLs or action levels.

Table 3: Treatment goals for McKittrick area groundwater

Constituent	Concentration range (mg/l)	Treatment goal (mg/l)	Regulated by
TDS	4,600 – 7,600	< 500	Primary MCL
Boron	16 – 26	< 1	Action Level
Chloride	1,200 – 1,600	250	Secondary MCL
Sulfate	900 – 1,500	250	Secondary MCL

Evaluation of Treatment Alternatives

As discussed in earlier sections, the McKittrick area groundwater is contaminated with high concentrations of TDS (6,100 mg/l), boron (21 mg/l), chloride (1,600 mg/l) and sulfate (1,200 mg/l). The treatment alternative must be capable of reducing the concentrations to levels that meet the identified drinking water standards.

Treatment for TDS reduction

Treatment processes such as distillation, membrane filtration, Electro Dialysis Reversal (EDR) and freeze thaw are used for desalting (TDS reduction) saline/brackish waters. Although EDR process is used in some Public Water Systems, it is not typically used for waters with high levels of TDS as found in McKittrick groundwater. Freeze thaw technology is very energy intensive and not used in any Public Water Systems. Distillation processes are sometimes used in desalination of seawater. Membrane technologies are sometimes used desalination of brackish and saline waters. Hence, although distillation processes are recognized as "Methods not used in Public Water Systems" and membrane technologies are listed as "Methods used in limited number of cases" by the EPA guidelines document, these two technologies were selected for preliminary evaluation in this study. Distillation technology includes Multistage Flash Distillation (MSF), Multiple Effect Distillation (MED), Mechanical Vapor Compression (MVC) and Steam Jet Type Vapor Compression. Membrane technologies for desalting may include Reverse Osmosis (RO) and Nano-Filtration (NF). Among the distillation technologies, Mechanical Vapor Compression (MVC) is the most energy efficient. Among the membrane technologies RO is the most effective process for removing dissolved ions from the water.

Treatment process for boron removal

In addition to TDS (including chloride and sulfate) removal, distillation and membrane technologies can remove boron by adjusting the operating conditions. For example, RO can effectively remove boron if the feed water pH is adjusted to about 10.5 to 11 (Kennedy/Jenks, 1997). About 90% of boron was removed from an oil field produced water containing 6,000 mg/l TDS and approximately 25 mg/l of boron in an earlier pilot scale study.

Ion-Exchange resins are also reported to remove boron from some waters. However, discussion with vendors indicated that most of the boron removal studies so far have been conducted for agricultural water uses where the TDS concentrations are significantly (about an order of magnitude) lower than that found in the McKittrick area groundwater. To date no study has been performed to evaluate boron removal from waters containing high levels of TDS. In addition, preliminary investigations indicated that the cost of treatment using ion-exchange resins is significantly higher than RO treatment with pH adjustment.

Selection of technologies for preliminary investigation

Based on the above considerations MVC and RO processes were selected for preliminary evaluation.

Distillation process – Mechanical Vapor Compression (MVC)

Mechanical vapor compression (MVC) is the most energy efficient distillation process for desalting brackish water. The heat for evaporating the water comes from the compression of vapor rather than the direct exchange of heat from steam produced in a boiler. The MVC process uses a mechanical compressor to condense vapor so as to produce enough heat to evaporate incoming water.

MVC units have been built in a variety of configurations to promote the exchange of heat to evaporate saline/brackish water. The MVC consists of a vessel with a tube bundle, mechanical compressor, heat exchanger, and pumps. The compressor creates a vacuum in the vessel and then compresses the vapor taken from the vessel. The vapor is then condensed inside of a tube bundle that is also in the same vessel. Feed water is sprayed on the outside of the heated tube bundle where it boils and partially evaporates, producing more vapor.

For most applications "low-temperature" MVC operates with an internal temperature of less than 150 °F (65 °C). This relatively low operating temperature, together with the scale control additive, reduces the scaling problems associated with higher temperature distillation processes.

However, if MVC were used to treat McKittrick area groundwater, the high concentrations of hardness and silica will require pretreatment, to minimize scaling of heat exchanger tubes. Pretreatment using a warm softening process (at pH > 9.5), with magnesium chloride addition may be used for hardness and silica removal. Pretreatment may be waived if MVC is operated in a 'seeded-slurry' mode. Seeded-slurry units combine pretreatment and evaporation in a single step by constantly recycling brine that has been seeded with calcium sulfate. Silica and other potentially scaling compounds precipitate onto the calcium sulfate seed crystals in the brine slurry rather than onto the heat transfer surfaces. The concentrators can be chemically cleaned in place.

The typical TDS concentration from MVC condensate is about 20 mg/l. The sulfate, chloride and boron concentrations are expected to be well below the treatment goals.

Membrane technology – Reverse Osmosis (RO)

RO is a membrane separation process in which the water from a pressurized saline solution is separated from the solutes (the dissolved material) by flowing through a membrane. No heating or phase change is necessary for this separation. The major energy required for desalting is for pressurizing the feed water.

In practice, the saline feed water is pumped into a closed vessel where it is pressurized against the membrane. As a portion of the water passes through the membrane, the remaining feed water increases in salt content. The amount of the feed water discharged to waste in this brine stream for brackish water varies from 10 to 40 percent of the feed flow, depending on the salt content of the feed water.

An RO system is made up of the following basic components:

- Pretreatment
- High-pressure pump
- Membrane assembly
- Post-treatment

Pretreatment is important in RO because the feed water must pass through very narrow spacings in the membrane. RO pretreatment typically consists of hardness and silica removal to minimize scaling problems, fine filtration, and the addition of acid or other chemicals to inhibit chemical precipitation or microbial growth. Hardness and silica may be reduced using a warm softening process (pH ~ 9.5) with the addition of magnesium chloride.

The pressure needed for the water to pass through the membrane is provided by high-pressure pumps. This pressure ranges from 17 to 27 bars (250 to 400 psi) for brackish water and from 54 to 80 bars (800 to 1,180 psi) for seawater.

The membrane assembly consists of a pressure vessel and a membrane that permits the feed water to be pressurized against the membrane. The membrane must be able to withstand the entire pressure differential across it. RO membranes are made in a variety of configurations. Two of the most commercially successful configurations are spiral-wound and hollow fine fiber. Both of these configurations are used to desalt brackish and sea water, although the construction of the membrane and pressure vessel will vary depending on the manufacturer and the expected salt content of the feed water.

Post-treatment of RO permeate is required to stabilize the water and prepare it for distribution. This post-treatment might consist of removing gases such as carbon dioxide and hydrogen sulfide, adjusting the pH and disinfection.

The RO process generates a large volume of reject (10 to 40% of feed) water. RO reject water needs to be disposed safely and economically. Discharge to sanitary sewers, deep well injection, and solar evaporation are some of the options used for disposal of RO reject water.

Although TDS can be reduced effectively using RO as a wide range of pH, Kennedy/Jenks experience (Kennedy/Jenks, 1997) indicates that effective boron removal can be achieved at a pH of about 10.5. Hence, a typical process stream for the treatment of McKittrick area groundwater may consist of a warm softening unit, pressure filtration, cartridge filtration, RO, stabilization, pH adjustment and disinfection.

Reverse osmosis versus distillation technologies

Treatment technologies to remove dissolved salt from water include thermal distillation and membrane processes. Within the desalination industry, membrane technologies such as reverse osmosis (RO) are generally the technology of choice for brackish applications, while both distillation and membrane processes are considered competitive for higher salinity waters such as sea water. Selecting the appropriate desalting technology for a particular project depends to a large extent on specific conditions and requirements of the project.

Preliminary cost evaluation of MVC and membrane processes

Planning level costs for the two treatment systems were obtained from Kennedy/Jenks experience with similar projects, vendors and cost-estimating computer models. Kennedy/Jenks pervious experience with these technologies evaluated treatment costs was a flow rate for 1.8 MGD (Kennedy/Jenks, 1997). This flow is similar to current potable water demand in the McKittrick area of about 1.5 MGD. Hence, this flow rate was used in the preliminary treatment cost evaluations. Treatment costs were compared based on capital cost, operation and maintenance (O&M) cost, and total annual cost (sum of amortized capital and operational costs). Capital costs were amortized over 20 years at an interest rate of 7 percent per year, yielding a capital recovery factor of 0.0936. These amortization rates are typical for municipal water utilities that often finance capital expenses through bonds.

Tables 4 through 9 list the components of planning level capital and annual costs for the three treatment trains. Table 4 lists generic cost assumptions and Table 5 presents technology-specific design parameters used to estimate treatment costs. Table 6 presents planning level cost comparisons of the treatment options, reverse osmosis with pretreatment, MVC with pretreatment, and seeded-slurry MVC that does not require extensive pretreatment. The cost estimates have an accuracy of approximately -30 to + 50 percent.

Total capital costs listed include equipment and direct construction costs (50 percent of equipment) such as installation cost, as well as indirect costs (38 percent of equipment and construction costs) such as legal fees and administration. Operating costs include chemicals, sludge disposal, reject disposal, energy, and labor. Annual costs and unit costs include amortized capital and operation and maintenance costs.

Table 4: Values assigned to generic cost factor

Parameter	Value	Unit
Capital		
Dollar	2002	index year
Mobilization and Bonding, Site Preparation, Contractor's Overhead and Profit, and Contingencies	50	percent of facilities costs
Indirect Costs, including Legal and Administrative	38	percent of construction bid costs
Interest Rate	7	percent/annum
Capital Recovery Period	20	years
O&M		
Electricity Rate	0.10	$ per kW hr
Labor Rate	30	$ per hr

Table 5: Design parameters assumed for cost estimation

Technology	Design assumptions
Warm precipitative softening	NaOH dosage 700 mg/l $MgCl_2$ 40 mg/l NaOH $0.2 / lb; $MgCl_2$ $0.26 / lb Sludge disposal $55/ton (dry)
Cooling	Based on packed tower with A/W = 50:1
Sand filtration	Hydraulic loading rate = 5 gpm/ft^2
RO	Membrane replacement every 18 months 500- 8" x 40" elements at $800/element 4 kWh/1000 gallon treated Reject disposal $1.18/1000 gallon
MVC	140 kWh/1000 gallon treated

Table 6: Planning level cost estimates for 1.8 MGD Reverse Osmosis and Vapor Compression Systems

Desalting technology	Treated water recovery (percent of 1.8 MGD)	Total capital cost (million 2002 dollars)	Annual operating costs (million 2002 dollars/yr)	Total annual cost (million 2002 dollars/yr)	Total unit cost (2002 dollars/AF of water produced)
Reverse Osmosis, including pretreatment	80	11	2.4	3.3	2,200
Mechanical Vapor Compression, including pretreatment	90	33	11	14.2	9,400
Mechanical Vapor Compression, seeded slurry	98	31	12	15.2	7,900

MGD – Million gallons per day; AF – acre-foot

Table 7: Cost breakdown for Reverse Osmosis system

Process	Total capital cost (million 2002 $)	Annual operations cost (thousand 2002 $)	Total annual cost (thousand 2002 $)	Total unit cost (2002 $/AF of water produced)
Warm softening	2.7	1,400	1,600	1,000
Cooling	0.7	70	100	60
Sand filtration	1.5	150	300	190
Reverse Osmosis	5.7	670	1,250	810
Stabilization	0.12	20	30	20
Disinfection	0.12	50	60	40
Total	**11**	**2,400**	**3,500**	**2,300**

Table 8: Cost breakdown for Vapor Compression System with pretreatment

Process	Total capital cost (million 2002 $)	Annual operations cost (thousand 2002 $)	Total annual cost (thousand 2002 $)	Total unit cost (2002 $/AF of water produced)
Warm softening	2.7	1,400	1,600	1,050
Sand filtration	1.5	150	300	190
Vapor compression	28.2	9,400	12,000	7,900
Cooling	0.6	60	100	70
Stabilization	0.12	20	30	20
Disinfection	0.12	50	60	40
Total	**33**	**11,200**	**14,500**	**9,400**

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Table 9: Cost breakdown for 'Seeded-Slurry' Vapor Compression System without pretreatment

Process	Total capital cost (million 2002 $)	Annual operations cost (thousand 2002 $)	Total annual cost (thousand 2002 $)	Total unit cost (2002 $/AF of water produced)
Vapor compression	29.8	12,000	14,900	7,800
Cooling	0.7	70	130	70
Stabilization	0.12	20	30	20
Disinfection	0.12	50	60	30
Total	**31**	**12,200**	**15,200**	**8,000**

Capital costs

The planning level capital costs for RO, MVC with pretreatment, and 'seeded-slurry' MVC units are $10 million, $33 million and $32 million, respectively. The capital costs for MVC systems are approximately 3.2 times larger than capital costs for RO systems.

Operating costs

The major operating cost for RO and a large cost for MVC is precipitative softening pretreatment. Sludge disposal and chemical costs for caustic soda and magnesium chloride account for a significant portion of the costs. Costs were estimated for precipitative softening based on a sodium hydroxide dosage of 700 mg/L and a magnesium chloride dosage of 40 mg/L. These costs were used for MVC with pretreatment also.

Electricity is the primary operating cost for MVC and a major operating cost for RO. For brackish water applications, RO is much more energy efficient than MVC. Typical energy usage rates are 1 to 10 kWh/1000 gallon for RO compared to 35 to 150 kWh/gallon for MVC. Treating 1.8 MGD with an electricity cost of $0.10 per kWh, an RO process that requires 4kWh/1000 gallon uses $0.26 million per year of electricity, while a MVC process that requires 140 kWh/1000 gallon uses $9.2 million per year of electricity.

Membrane replacement costs are also significant for RO. Assuming a membrane life of thirty months, the membrane replacement costs represents approximately twenty five to thirty percent of RO annual operating costs.

Total annual costs

Total annual costs for vapor compression are approximately 4 times larger than total annual costs for reverse osmosis. In terms of cost per acre-ft of treated water produced, vapor compression is approximately 3.5 to 4.0 times more expensive. Costs measured this way reflect the water recovery of the treatment process. For example, RO produces 1.4 MGD of treated water from 1.8 MGD of feed water, while MVC produces in excess of 1.6 MGD from 1.8 MGD of feed water.

Selection of treatment for planning level cost estimates

Reverse Osmosis is selected for detailed evaluation for treating McKittrick area groundwater in this study for the following reasons:

- RO treatment cost is significantly lower than the cost of treatment using MVC, and
- RO is recognized by the EPA guidance document as a treatment process used in public water system whereas distillation is not recognized as a commonly used treatment system by a public water system.

SECTION 3. TREATMENT COST EVALUATION FOR McKITTRICK AREA GROUNDWATER

Design Flow Estimation for Treatment Cost Evaluation

The following four criteria were evaluated in arriving at the design flow for RO treatment of McKittrick groundwater:

- Average population served by groundwater utility in California: The EPA document proposes the water demand of an average population served by the groundwater utilities in the home state as one of the criteria for selecting design flow for economic evaluation. In 1986, the average population served by groundwater utility is about 1,799 in California. Based on groundwater quality database received from the California Department of Health Services, the average population served in 2002 is about 3,600. Assuming a demand of 150 gallons per capita per day, the demand is about 540,000 gpd (0.54 MGD).
- Sustainable yield of the aquifer: The second criteria recommended by EPA for the selection of design flow is the sustainable yield of the aquifer. However, no data is currently available on the sustainable yield of the McKittrick area groundwater aquifer.
- Local demand: Preliminary discussions with the local water agencies indicated that the current water demand for the McKittrick area is about 1.5 MGD of potable water. The demand is estimated to increase to 2.0 MGD by the year 2020.
- Other local limitations: Several limitations exist in the McKittrick area for the disposal of reject stream from RO and other desalting operations. The area is not currently served by sewer systems. Hence, the reject cannot be disposed in a collection system for treatment. The only viable option for disposal of liquid waste, other than groundwater injection or crystallization, is to dispose of the reject in a Class 2 Waste Management facility in the local area. This facility uses solar evaporation ponds to concentrate liquid wastes. Currently, the facility is permitted to receive a total of 100,000 gpd of liquid waste from all sources. It is not known if the permit levels can be increased in future based on increased demand. RO treatment typically generates 20-25% of the treated volume as reject. If the design treatment capacity selected is such that it generates more than 50,000 gpd reject water, a concentration process (solar pond, distillation unit) may be required to reduce the waste volume, prior to disposing the liquid waste in the Waste Management facility.

Design flow rates selected for this study

Based on the above limitations, the following two flow rates were selected for economic evaluation in this study.

- Design flow of approximately 165,000 gpd. A computer model for RO treatment provided by a vendor indicated that treatment of McKittrick groundwater may generate approximately 30% of reject water. A feed water flow of 165,000 gpd will generate a reject volume of about 50,000 gpd. In this case, reject disposal cost is estimated assuming that the reject will be sent to the Waste Management facility without further concentration.
- Design flow of about 2.85 MGD. A 30% rejection of the feed water will generate about 2 MGD (the future demand for this area) and a reject of about 850,000 gpd. In this case it is assumed that the reject will be concentrated to about 50,000 gpd using an evaporator-concentration (vapor compression) process prior to disposal in the Waste Management facility.

Table 10 summarizes the design flow rate and RO reject options selected for this study.

Table 10: Design flow rates selected for McKittrick groundwater treatment

Design flow rate (gpd)	Anticipated RO reject (gpd)	Reject disposal option
250,000	50,000	Direct disposal into Waste Management facility for solar evaporation
2,850,000	850,000	On site concentration to 50,000 gpd followed by disposal to Waste Management facility for solar evaporation

Costs Considered in Economic Evaluation

This section provides a broad overview of items included in the economic evaluation in this study. Costs that are not included are also listed. Detailed breakdown of costs, assumptions made and sources of information are provided in subsequent sections on treatment cost estimation and in Appendix A.

The following are included in the economic evaluation:

- Treatment process costs included pretreatment, primary treatment, post treatment, sludge/waste disposal, disinfection cost.
- The costs for a pumping system to deliver treated water to the distribution system are also included in the cost estimate. A delivery pressure of 80 psi with subsequent distribution using the existing distribution system was assumed in the cost estimation.
- In evaluating water rates, the EPA document specifies an increase in annual household rate of $300 as the benchmark for classifying the groundwater as Class III. The EPA report was developed in 1986. In this study (McKittrick area groundwater treatment), this amount is adjusted to 2002 dollars using 'Engineering News Report – Construction Cost Index'. Accordingly, the revised cost criteria used in Class III definition in this report is $455.

The following items were not included in the evaluation:

- Potential increase in cost due to 'Homeland Security' requirements is not included in this report.
- It is assumed that the treated water will be delivered to the customers using the existing distribution network in the McKittrick area. Hence, treated water delivery cost (43% of water treatment cost, as per EPA document) is not included in the economic evaluation.

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Detailed Evaluation of RO Treatment Process for McKittrick Area groundwater

Figure 1 shows simplified process diagrams for the treatment of McKittrick area groundwater at flow rates of 250,000 and 2,850,000 gpd, respectively. The following sections provide a discussion of each of the process units, rationale behind their selection, operational conditions and design considerations. A planning level capital, annual O&M and total annual cost for treatment at the two flow rates are also summarized. Table 11 shows the cost factors used in the treatment cost estimates. Table 12 provides the design criteria used in two treatment processes.

Table 11: Values assigned to generic cost factor

Parameter	Value	Unit
Capital		
Dollar	2002	index year
Mobilization and bonding, site preparation, contractor's overhead and profit, and contingencies	50	percent of facilities costs
Indirect costs, including legal and administrative	38	percent of construction bid costs
Interest rate	7	percent/annum
Capital recovery period	20	years
O&M		
Electricity rate	0.10	$ per kW hr
Labor rate	32	$ per hr
Lime	0.11	$ per lb
Anti scalent	1.50	$ per lb
Coagulant (cationic polymer)	2.66	$ per lb
Sulfuric acid	0.05	$ per lb
Sodium hypochlorite	0.79	$ per lb
Cartridge	25	$ per cartridge
RO membrane elements	700	$ per element
Sludge disposal	48.15	$/ton sludge
RO reject disposal	0.21	$ per gallon

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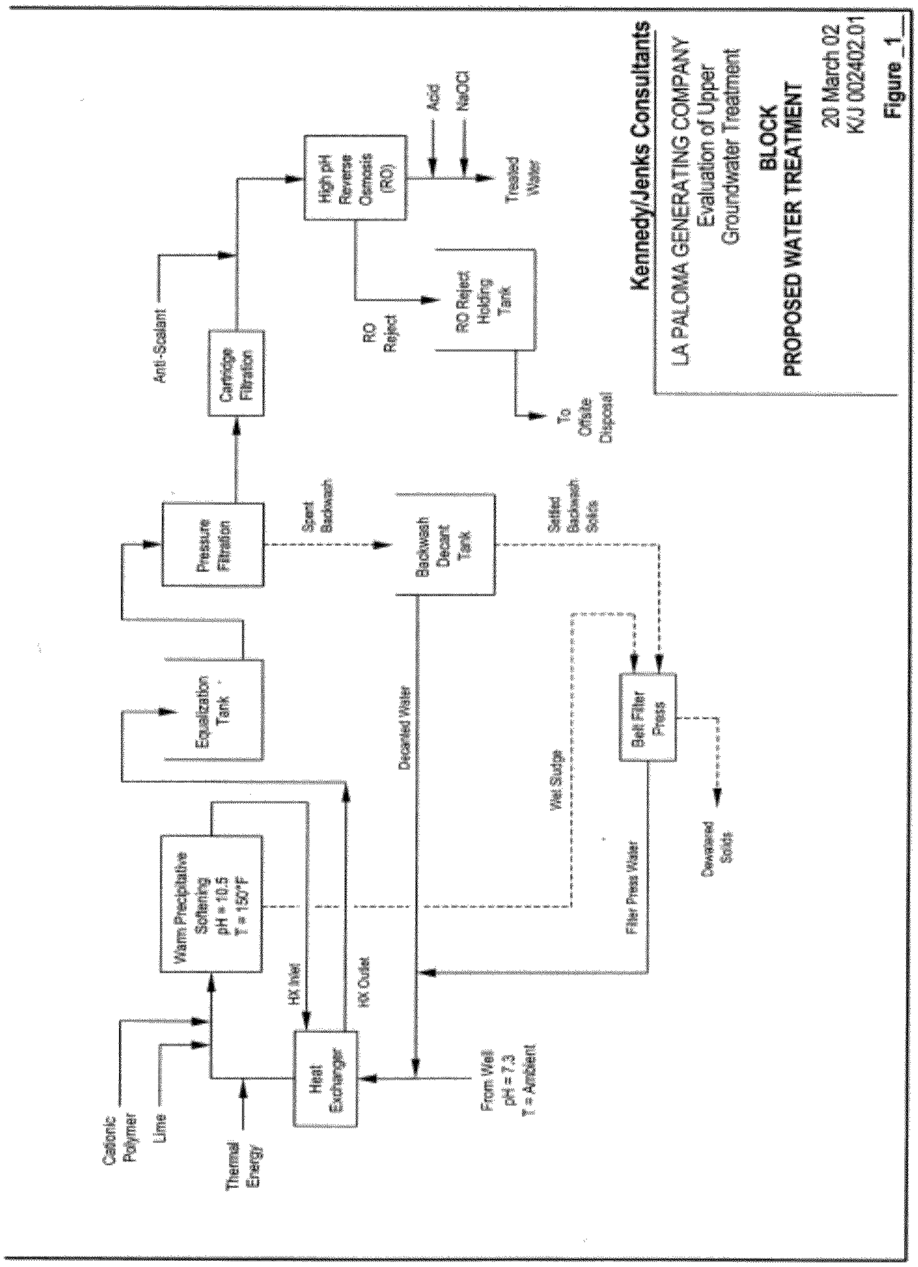

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Table 12: Design criteria used for the treatment of McKittrick area groundwater

Process parameter	Units	165,000 gpd system	2.85 MGD system
Flow rate from well production	gpd	165,000	2,850,000
Flow rate of treated water	gpd	115,000	2,000,000
Overall water recovery	Percent	70	70
WARM PRECIPITATIVE SOFTENING			
Operating pH	-	10.5	10.5
DensaDeg clarifier			
Flow rate	gpd	165,000	2,850,000
Depth	ft.	17	17.5
Reaction vessel			
diameter	ft.	3	13
volume	Gallons	1,100	17,400
detention time	min.	10	8.8
Thickener/clarifier			
Diameter	ft.	4.5	21
Volume	Gallons	2,100	44,000
Detention time	min.	18.5	22
Settling zone area	sq.ft.	16.5	231
Surface loading rate	gpm/sq.ft.	7	8.6
CHEMICAL SYSTEMS			
Lime			
Dosage, avg.	mg/L	755	755
Use, avg.	lb/day	1,050	18,000
Polymer			
Dosage, avg.	mg/L	3.5	3.5
Use, avg.	lb/day	5.4	91.7
Sludge handling and treatment			
Wet sludge production	ton/day	27	460
Wet sludge volume	gpd	6,000	103,000
Percent solids	%	6.0	6.0
Sludge filter press			
Type	-	Belt filter press	Belt filter press
Dewatered sludge percent solids	%.	28	28
Dewatered sludge	ton/day	6	100

Process parameter	Units	165,000 gpd system	2.85 MGD system
EQUALIZATION STORAGE			
Volume	gal	850	7,000
BOOSTER PUMPING			
Pumping capacity	gpd	115,000	2,000,000
Discharge pressure	psig	80	80
pH ADJUSTMENT (STABILIZATION)			
Sulfuric acid (93%)			
Dosage, avg.	mg/L	3.2	3.2
Use, avg.	lb/day	4.5	76.3
PRESSURE FILTRATION			
Number of units	-	2	8
Diameter	ft.	8	8
Surface loading rate	gpm/sq.ft.	2.3	5.6
Media depths			
0.85-0.95 mm anthracite	inches	3.5	3.5
No. 20 sand	inches	5	5
Garnet (30 x 40 mesh screen)	inches	12.5	12.5
Garnet (8 x 12 mesh screen)	inches	21.5	21.5
Gravel underdrain	inches	7.5	7.5
CARTRIDGE FILTRATION			
Cartridge type	-	Spiral wound	Spiral wound
Number	-	15	175
Nominal sized particle removed	µm	5	5
Replacement frequency	day	14	14
REVERSE OSMOSIS			
Operating RO feed pH	std. units	10.5	10.5
Flow rates			
feed flow rate	gpm	115	1,980
recycle flow rate	gpm	0	0
permeate flow rate	gpm	80	1,385
reject flow rate	gpm	35	595
Membrane Elements			
Number	-	30	324
Array scheme	-	3x2	3x2
Type	-	Spiral wound	Spiral wound

Process parameter	Units	165,000 gpd system	2.85 MGD system
Diameter	inch	8	8
Length	inch	40	40
Chemical systems			
Scale Inhibitor			
Dosage, avg.	mg/L	5.0	5.0
Use, avg./max.	lb/day	7.0	120.0
DISINFECTION/STORAGE			
Sodium hypochlorite system			
Dosage, avg.	mg/L	2.0	2.0
Use, avg.	lb/day	2.8	47.7

Warm softening for hardness and silica reduction

The first stage of treatment process includes a warm precipitative softening for hardness and silica removal. A softening process is required to minimize calcium and silica fouling of the RO membrane and increase the RO yield. Lime is the precipitant of choice for the softening process due to lower cost. Warm precipitation (150 °F), rather than ambient precipitation, is chosen due to lower solubility of calcium and silica at elevated temperatures. Enhanced removal of hardness and silica is required to minimize fouling of RO membranes.

The operating temperature will be around 150 °F. Incoming water at ambient temperature will initially be heated to 115 °F using the clarifier effluent in a heat exchange unit. The water will further be heated to 150 °F using steam delivered from a nearby oil production field. Chemical additions will include lime to control pH to 9.7± (average of 440 mg/L) with an anionic polymer (average of 3.5 mg/L) added to assist with settling of the precipitate. The process will produce approximately 27 tons of wet sludge from the smaller unit and 460 tons of wet sludge from the bigger unit daily. The sludge will be dewatered to by a filter press and hauled to the Waste Management facility. The dewatered sludge will contain approximately 28% of solids.

Warm softening unit for 165,000 gpd influent flow

Warm precipitative softening will be carried out in a DensaDeg clarifier. This unit consists of three components; namely, a rapid mix chamber, a reaction tank, and a thickener/clarifier. The rapid mix chamber consists of a 3-ft. diameter draft tube in which a turbine mixer provides initial mixing of precipitation chemicals. The rapid mix chamber is composed of a 2 ft. diameter by 17 ft. high cylindrical tank and a Lightnin' model XJQ-117 mixer powered by a 1.17 hp 1,800 rpm Duramix motor. The mixer imparts approximately 1,200 sec^{-1} of velocity gradient. The reaction tank is made up of a 3½ ft. diameter by 17 ft. high outer tank, a 1.5 ft. diameter by 15 ft. high inner cylinder, a 3 ft. 3 inch by 15 ft. baffle plate, and a Lightnin' model V5 6Q150 mixer powered by a 2 hp variable speed motor. The thickener/clarifier consists of a 2,100-gallon tank separated into a downflow thickener section and an upflow clarifier section, lamellar tube settlers at the top of the clarifier, and a 0.5 rpm sludge scraper powered by a 0.5 hp Sew Eurodrive motor. The DensaDeg also has a sludge recirculation pump to return a portion of the developed solids from the thickener section of the thickener/clarifier back to the inner cylinder of the reaction tank. The sludge recirculation pump is a Moyno Progressive Cavity pump powered by a Sterling 3 hp variable speed motor.

Warm precipitation unit for 2.85 MGD influent flow

A DensaDeg clarifier will be used for warm precipitative softening in this case also. The rapid mix chamber consists of a 3-ft. diameter draft tube in which a turbine mixer provides initial mixing of precipitation chemicals. The rapid mix chamber is inside a 12.5-ft. x 17 ft. deep reaction tank. The detention time at the design flow would be approximately10 minutes. The thickener/clarifier has a 21-ft. diameter, a 17-ft. water depth, and a 25-minute detention time at design flow. The clarified water then exists the clarifier through plate settlers with a loading rate of 6.75 gpm/sq.ft.

DensaDeg effluent quality

Based on Kennedy/Jenks experience and model results, it is anticipated that the DensaDeg effluent will have a total hardness of about 100 mg/l (about 91% removal), silica 20 mg/l (about 47% removal), and boron 10 mg/l (52% removal). The TDS (6,100 mg/l) and alkalinity (550 mg/l) are not significantly reduced in the DensaDeg process.

DensaDeg sludge disposal

The DensaDeg sludge is anticipated to contain 6% solids and 3.5% influent volume. The smaller flow rate process (165,000 gpd) is expected to generate 27 tons of solids and the larger flow rate case is expected to generate 460 tons of solids per day. The sludge will be thickened using a filter press. The smaller unit will have a 1 meter wide belt, 15 hp filter press and the larger unit will have a 2 meter wide, 22 hp filter press. As per vendor information the sludge cake from the filter press will have about 20 to 28% solids. About 6 tons of dry sludge will be generate from the smaller unit and 100 tons dry sludge will be generated from the larger unit daily.

Evaluation of DensaDeg sludge quality from similar water by Kennedy/Jenks in an earlier project indicated that concentration of metals will not constitute the sludge to be classified as hazardous. There are two facilities in the project area that can receive non-hazardous solid wastes for disposal. One is the Taft Landfill, a Class 3 facility managed by the Kern County Resource Management Agency and the other is the Waste Management, Class 2 facility. The Taft Landfill requires the sludge to contain at least 50 % solids. The Waste Management facility accepts sludge containing lower solids concentration. The filter press cake will contain about 28% solids. Hence, for this study, it is assumed that the sludge will be disposed in the Waste Management facility.

Cooling

The temperature of the warm softening effluent will be near 145 °F. Information from RO vendors suggests that the membrane can operate efficiently up to a feed water temperature of about 115 °F. Hence, the DensaDeg water will be cooled to 115 °F prior to RO treatment using a heat exchanger. This cooling will be facilitated by the groundwater entering the treatment process at ambient temperature (Figure 1).

Equalization tank

The cooled water (115 ° F) will be routed to an equalization tank which will allow the temperature of the softened water to be equalized. For 165,000 gpd flow, an 850 gallon tank will be used. For the 2.85 MGD flow, a 7,000 gallon tank will be used. Water from the storage tank will be pumped to pressure filters.

Pressure filter

The pumped water will be filtered by polishing multi-media filters consisting of layers of anthracite, sand, and garnet media.

Pressure filtration for 250,000 gpd flow

Two multimedia pressure filters (8 feet diameter) will be operated to remove the solids. One of the two filters will be used as a standby unit. The design maximum hydraulic loading rate for the filters is approximately 5 gpm/ft^2. For this study, it is assumed that the units will be operated at a loading rate of 2.8 gpm/ft^2. Chemtreat P-822L, a cationic polyamine polymer filter aid manufactured by ChemTreat, will be added to the filter influent during the later stages of phase three testing. Dosing rates for the filter aid will range from 1.5 to 8.6 ppm (volume/volume basis). The filters will be backwashed at periodic intervals with reverse osmosis permeate.

Pressure filtration for 2.85 MGD flow

There will be eight 8-ft diameter pressure units used in parallel mode for this operation. Six of the units will be used at maximum flow conditions and two will be used as stand-by units. The loading rate will be about 4 gpm/ft^2.The filter units will be plumbed so that two units can be backwashed with the filtrate being generated by the other six units. The spent washwater will be routed to the head end of the DensaDeg.

Reverse Osmosis (RO)

The filtered water will be routed to the RO units, which will include pre-cartridge filtration and chemical pretreatment consisting of pH adjustment, scale inhibition, and organic fouling control.

RO for 250,000 gpd flow

Reverse osmosis will be the final unit in the treatment process as shown in Figure 1. It will consist of the following components: fifty five 8" x 40" brackish water spiral wound membrane elements housed in 5 pressure vessels arranged in a 2-stage (3 x 2) array; three interchangeable banks of 5-micron filters that precede the membrane elements; a high pressure pump; and a recycle line that return a portion of the reject stream to the incoming feed. The feed water pH will be about 10.5. Based on model results and membrane vendor information, a permeate recovery of 70% may be expected for McKittrick area groundwater treatment. The unit typically will operate at feed pressures from 220 psig.

RO for 2.85 MGD flow

The RO units will be run in a two-stage array, with 70 percent recovery and a 50 percent (based on feed flow) recycle ratio. The array will consist of 324 eight-inch diameter thin film composite

RO elements. The RO feed water will be at a pH of about 10.5. An antiscalant (5 mg/L average) will be used.

RO permeate water quality

Based on Kennedy/Jenks experience and vendor information, the TDS of RO effluent is expected to be about 150 mg/l and boron concentration is expected to be less than 2 mg/l. Permeate boron concentration may still be higher than the Action Level of 1 mg/l.

RO reject disposal

As discussed in an earlier section, the lower flow rate scenario will generate about 50,000 gpd of reject water. Currently there are no sewer systems in the McKittrick area and hence, the option of disposing RO reject into sanitary sewer does not exist. The Waste Management facility in McKittrick is permitted to receive non-hazardous liquid waste from generators. The liquid waste is treated by solar evaporation in this facility. Currently this facility is permitted to receive a maximum of 100,000 gpd liquid waste. For the lower flow rate evaluation, it is assumed that the reject will be shipped to this facility.

The 2.85 MGD operation will generate about 850,000 gpd RO reject. This is significantly higher than the permitted capacity of the Waste Management Waste Disposal facility. Hence, it is assumed that the reject will be concentrated using an 'evaporator-concentrator unit' (similar to the unit installed in the Plant) to 50,000 gpd and the concentrated reject (50,000 gpd) shipped to the Waste Management facility.

Water stabilization

The pH of the RO permeate will be adjusted downward with sulfuric acid (59 mg/L average) so that the water is stable with respect to scaling.

Disinfection

Disinfection will be accomplished by sodium hypochlorite. Sufficient chlorine will be applied to produce a 2.0 mg/L residual.

Summary of water quality characteristics of various process units

Table 13 summarizes the anticipated water quality characteristics at various locations in the proposed treatment process. The DensaDeg unit is expected to remove about 90% of the hardness, 50% of boron and 50% of silica. The RO unit is expected to remove more than 99% of hardness, 97% of TDS, 95% of silica and 80% boron. The treated effluent is expected to contain about 150 mg/l TDS and less than 2 mg/l boron. Kennedy/Jenks earlier experience with treatment of similar waters did not yield a boron concentration of < 1.9 mg/l in the RO permeate. The following may be evaluated to decrease the boron concentration to below 1 mg/l:

- Increasing the number of stages in the RO process
- Using boron specific ion-exchange process to treat the RO permeate, or
- Blending the permeate with boron free water from another source.

All of these options will involve additional treatment cost to that included in this study. The sulfate and chloride levels in the RO permeate are expected to be below the regulatory limits.

Table 13: Anticipated water quality characteristics in various treatment units

	Hardness (mg/l)	TDS (mg/l)	pH	Silica (mg/l)	Boron (B)	Alkalinity (mg/l as $CaCO_3$)
Influent	1,100	6,100	7.3	38	21	550
DensaDeg effluent	100	6,100	10.5	20	10	550
RO product	< 1	150	10.5	< 1	< 2	85
pH stabilization	<1	150	7.5	<1	<2	60

Treatment cost

Tables 14 through 16 show the capital cost, annual O&M cost and total annual cost (amortized capital cost + annual O&M cost) for the 250,000 gpd system and the 2.85 MGD system. The capital cost of the smaller system is about $1.6 million and for the larger system is about $27.6 million. The annual O&M cost for the two systems are $4.3 million and $9.1 million, respectively. The treatment cost per acre-foot of treated water is about $34,500 for the smaller flow rate and $5,800 for the larger flow rate. The higher cost for the larger system is predominantly due to the cost of the evaporator unit to concentrate the RO reject. The high O&M cost for the two systems are predominantly due to the cost for disposing the RO reject ($0.21/gal). The electricity cost evaporator-concentrator for the larger system is also a significant factor.

Table 14: RO treatment cost summary for McKittrick area groundwater

System	Treated water (gpd)	Capital cost ($ 1000)	Annual O&M cost ($ 1000)	Total annual cost ($ 1000)	Treated water cost ($/AF)
Low flow rate	115	1,600	4,300	4,450	34,500
High flow rate	2,000	27,700	10,400	13,000	5,800

Table 15: Capital cost breakdown for RO treatment of McKittrick groundwater

Description	165,000 gpd system ($ 1000)	2.85 MGD system ($ 1000)
Heat exchanger	6.2	68
Steam pipe	127	154

Description	165,000 gpd system ($ 1000)	2.85 MGD system ($ 1000)
Warm softener	204.5	312
Equalization tank	3	135
Pressure filter	60	204
RO system	153	1,517
Backwash tank	20	74
Belt filter press	162	196
Booster pump, pipes and fitting	10.5	503
Evaporator-concentrator		8,600
Other direct construction cost (@ 25% of the equipment costs)	217	4,200
Contractor markup (@ 24% of the equipment and direct costs)	202	3,820
Indirect cost (@ 38% of the above costs)	400	7,500
Total capital cost	**1,600**	**27,400**

Table 16: O&M cost breakdown for RO treatment of McKittrick groundwater

Description	165,000 gpd system ($)	2.85 MGD system ($)
Chemicals		
Lime	43,000	730,000
Polymer	5,200	89,000
Antiscalent	3,800	65,000
Sulfuric acid	80	1,400
Sodium hypochlorite	800	14,000

Description	165,000 gpd system ($)	2.85 MGD system ($)
Cartridge filters	20,000	114,000
RO membrane elements	28,000	170,000
Labor	280,000	280,000
Maintenance	17,000	19,000
Electricity	42,000	3,400,000
Sludge disposal	100,000	1,700,000
RO reject disposal	3,800,000	3,800,000
Miscellaneous	10,000	20,000
Total annual O&M	**4,300,000**	**10,400,000**

Economic Evaluation

Comparison of treatment cost with current potable water cost

Table 17 shows the cost per acre-foot of water for the two flow rates. The current potable water cost in the project area is also given for comparison. The cost for groundwater treatment represents only the treatment cost. It does not include items such as land acquisition cost, well development cost, management cost, etc. As shown in the table, the treatment cost for the groundwater is 10 to 70 folds higher than the prevailing potable water cost in the McKittrick area.

Table 17: Current potable water cost and estimated groundwater treatment cost for McKittrick area

Item	Approximate cost ($/Acre-foot)
Current Water Cost at McKittrick Area	500
McKittrick area groundwater treatment (165,000 gpd)	34,500
McKittrick area groundwater treatment (2.85 MGD)	5,800

Evaluation of total water supply system cost for exceedance of threshold limit

One of the criteria recommended by EPA guidelines for groundwater classification for class III water is that the per household share of the annual total treatment system cost should not exceed 0.4 % of the annual household income of the region. The EPA document indicates that the total system cost should include i) acquisition cost (22% of treatment cost) which consists of land acquisition, well development and testing, ii) distribution system development cost (43% of treatment cost) and iii) service cost (17% of the treatment cost) in estimating the total treatment system cost. Since the McKittrick area already has a water distribution system, the distribution system development cost is not included in the treatment system development cost in this report. Only the acquisition cost and service cost were added to the treatment cost to estimate the total system cost. Table 18 shows the details of total system cost estimate. The total annual system cost (amortized treatment system cost + annual O&M cost) is about $6,200 and $18,000 for the treatment of McKittrick area groundwater at flow rates of 165,000 gpd and 2.85 MGD, respectively.

The 165,000 gpd can serve a population of 770 and the 2.85 MGD system can serve a population of 13,300. The year 2000 census indicates that as an average Kern County (which includes McKittrick area) has 3.03 members per household and the annual household income is about $32,359. Accordingly, the annual water cost per household is about $24,500 and $4,100 for the 165,000 and 2.85 MGD systems, respectively. This is about 75 and 13 % of the annual income in the McKittrick area. Based on this estimate, the McKittrick area meets the criteria provided by the EPA document to be designated as Class III (groundwater not a source of drinking water) water.

Table 18: Evaluation of total water supply system cost as a percentage of annual household income in McKittrick area

Description	165,000 gpd system	2.85 MGD system
Annual treatment cost ($ 1000)	4,450	13,000
Acquisition cost ($ 1000, @ 22% of treatment cost)	975	2,850
Service cost $ 1000, (@ 17% of treatment Cost)	750	2,200
Total system annual cost ($ 1000)	6,200	18,000
Population served	770	13,300
No. of persons in a household[1]	3.03	3.03
No. of households served	253	4,400
Annual system cost/household ($)	24,500	4,100
Median household Income ($)[1]	32,359	32,359
Annual cost as % of household Income	75	13
Exceeds EPA threshold limit	Yes	Yes

[1] Information obtained from Year 2000 census data for Kern County, CA.

Evaluation of treatment process cost for increase in annual water rate

A second criteria provided by EPA for Class III groundwater classification is that the increase in annual water cost per household should not be more than 100% or $455/per year. The current customers in the McKittrick area pay about $500/AF for potable water. Assuming a per capita water consumption of 150 gpd and an average number of people per household to be about 3.03, the current annual water cost per average household is about $255. The increase in water cost per household per year due to increase in treatment cost is about $17,345 for the smaller system and $2,695 for the larger system (Table 19). These amounts are more than 100% of the current water rate for an average household in the McKittrick area. Also, the increase in water cost will be more than $455/year for an average household. Based on this evaluation, the McKittrick area meets the criteria provided by the EPA document to be designated as Class III (groundwater not a source of drinking water) water.

Table 19: Impact of treatment process cost on annual water rate in McKittrick area

Description	165,000 gpd system	2.85 MGD system
Treatment cost ($/Acre Foot)	34,500	5,800
Current water charges ($/AF)	500	500
Current average household water cost ($)[1]	255	255
Household cost due to McKittrick groundwater treatment ($)	17,600	2,950
Increase in annual water charges ($)	17,345	2,695
Exceedance of EPA threshold water cost criteria (0.4% of annual income)	Yes	Yes
Percent increase in annual water cost (%)	6,900	1,050
Exceedance of EPA threshold water cost criteria (100% of current water cost)	Yes	Yes

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SECTION 4. CONCLUSIONS

This project evaluated the economic feasibility of treating the McKittrick area groundwater for use as drinking water. Analyses of water quality characteristics indicated that the groundwater is contaminated with high levels of TDS (6,100 mg/l), boron (21 mg/l), chloride (1,600 mg/l) and sulfate (1,200 mg/l). Based on preliminary technical and economic evaluation and site specific limitations, planning level costs (-30 to +50 %) were developed for RO treatment of the groundwater at 165,000 gpd and 2.85 MGD.

The cost of treated water per acre-foot is about $34,500 for the smaller system and $5,800 for the larger system. This is about 10 to 70 times more than the current potable water cost ($500/AF) in the McKittrick area. In addition, economic feasibility of treating the water was evaluated based on the guidelines provided by EPA for classification of groundwater as Class III (groundwater not a source of drinking water). The cost of developing groundwater system per household in the project area will be about 75% of the mean annual income for the smaller system and 13% of the annual income for the larger system, which are higher than the threshold limit recommended by EPA (0.4% of annual income). In addition, the increase in annual water rate per household due to the groundwater treatment will be about $17,500 for the smaller treatment system and $2,700 for the larger system, which are greater than the limits specified by the EPA document ($455). Based on these evaluations, the groundwater in the McKittrick area meets the criteria prescribed in the EPA document for groundwater classification to be designated as Class III (groundwater not a source of drinking water) water.

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APPENDIX A

DETAILS OF CAPITAL AND O&M COST BREAKUP FOR TREATING McKITTRICK GROUNDWATER AT THE TWO FLOW RATES

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TABLE A1. Capital costs for treatment system size based on 50,000 gpd Reverse Osmosis reject flow rate

ENGINEER'S COST ESTIMATE — KENNEDY/JENKS CONSULTANTS

Est By: SSH — Project: La Paloma — K/J Job No. — Date: 11-Mar-02

Task: **Capital Costs - Treatment System w/50,000 gpd Reject Stream** — Subdivision of Work: — Time: 10:20 AM

Type of Estimate: (X) Conceptual ( )Prelim. ( )Takeoff w/ Plans — __Current at ENR: — __Escalated at ENR:

Item No.	Description	Quantity	Unit	Material Unit Cost	Material Extension	Labor & Equip Unit Cost	Labor & Equip Extension	Subcontract Unit Cost	Subcontract Extension	Total Cost (2002 $) Unit Cost	Total Cost (2002 $) Extension
	Heat Exchanger - Plate and Frame Type	1	EA	$6,200.00	$6,200					$6,200.00	$6,200
	6-5/8" Dia Steam Line - Insulated w/Exterior Coating	2,640	LF					$48.14	$127,090	$48.14	$127,090
	Warm Lime Softener	1	EA	$200,000.00	$200,000					$200,000.00	$200,000
	Lime Feed System	1	EA	$3,000.00	$3,000					$3,000.00	$3,000
	Cationic Polymer Feed System	1	EA	$1,500.00	$1,500					$1,500.00	$1,500
	Equalization Tank (850 gal FRP)	1	EA	$1,000.00	$1,000					$1,000.00	$1,000
	Discharge Pump - Centrifugal	2	EA	$1,000.00	$2,000					$1,000.00	$2,000
	Pressure Filter - 8' dia; 75 psi rating	2	EA	$25,000.00	$50,000					$25,000.00	$50,000
	Filter Manifold	1	EA	$10,000.00	$10,000					$10,000.00	$10,000
	Backwash Pump - centrifugal	2	EA	$2,000.00	$4,000					$2,000.00	$4,000
	Reverse Osmosis (RO) System + Cartridge Filters	1	EA	$84,000.00	$84,000					$84,000.00	$84,000
	RO Reject Holding Tank (21,0000 gallons steel)	3	EA	$21,000.00	$63,000					$21,000.00	$63,000
	Anti-Scalant Feed System	1	EA	$2,000.00	$2,000					$2,000.00	$2,000
	Acid Feed System	1	EA	$1,500.00	$1,500					$1,500.00	$1,500
	Sodium Hypochlorite Feed System	1	EA	$3,000.00	$3,000					$3,000.00	$3,000
	Backwash Decant Tank (15,000 gal FRP)	1	EA	$15,000.00	$15,000					$15,000.00	$15,000
	Backwash Solids Transfer Pumps - progressive cavity	2	EA	$1,000.00	$2,000					$1,000.00	$2,000
	Decant Water Transfer Pumps - centrifugal	2	EA	$1,500.00	$3,000					$1,500.00	$3,000
	Belt Filter Press - 1 meter belt	1	EA	$160,000.00	$160,000					$160,000.00	$160,000
	Filter Press Water Transfer Pump - centrifugal	2	EA	$1,000.00	$2,000					$1,000.00	$2,000
	Booster Pump - centrifugal	2	EA	$1,500.00	$3,000					$1,500.00	$3,000
	Pipe (3-inch Sch 80 CPVC)	300	LF	$20.96	$6,288					$20.96	$6,288
	Fittings and Valves (20% of pipe cost)	1	EA	$1,257.60	$1,258					$1,257.60	$1,258

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TABLE A1. Capital costs for treatment system size based on 50,000 gpd Reverse Osmosis reject flow rate

ENGINEER'S COST ESTIMATE — KENNEDY/JENKS CONSULTANTS

Est By: SSH — Project: La Paloma — K/J Job No. — Date: 11-Mar-02

Task: **Capital Costs - Treatment System w/50,000 gpd Reject Stream** — Subdivision of Work: — Time: 10:20 AM

Type of Estimate: (X) Conceptual ( )Prelim. ( )Takeoff w/ Plans — __Current at ENR: — __Escalated at ENR:

1	Subtotal of Itemized Costs		$620,000	$0	$130,000	$750,000
2	Other Direct Construction Costs					
	Site Preparation (Site Clearing, Subsurface Preparation, etc.)	10.0%	$62,000	$0	$0	
	Site Development (Fencing, Paving, Landscaping, etc.)	10.0%	$62,000	$0	$0	
	Electrical and Instrumentation	15.0%	$93,000	$0	$0	
3	Direct Construction Subtotal		$840,000	$0	$130,000	$970,000
4	Contractor Markups					
	Mobilization and Bonding	2.0%	$17,000	$0	0	
	Contractor's Overhead and Profit (O&P)	12.0%	$101,000	$0	$16,000	
	Contingencies	10.0%	$84,000	$0	$13,000	
5	Total Construction Cost Estimate (Bid Cost)		$1,040,000	$0	$160,000	$1,200,000
6	Indirect Capital Cost Estimate (% of Bid Cost)	38.0%	$400,000	$0	$0	$400,000
7	**TOTAL CAPITAL COST ESTIMATE**					**$1,600,000**

Note: All Line Items Rounded to Two Significant Figures

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TABLE A2. O&M costs for treatment system size based on 50,000 gpd Reverse Osmosis reject flow rate

O&M	Quantity	Unit	Consumption Rate	Annual Total
System Flow Rates				
Raw Water	115.7	gpm		
RO Permeate	81.0	gpm		
RO Reject	34.7	gpm		
Consumables				
Chemicals				
DensaDeg Feed - Lime	0.11	$/lb	756.3 mg/l = 1,052 lbs/day	$43,000
DensaDeg Feed - Polymer	2.66	$/lb	3.5 ppm = 5.4 lbs/day	$5,200
Reverse Osmosis (RO) Feed - Antiscalant	1.50	$/lb	5 mg/l = 7.0 lbs/day	$3,800
RO Permeate - Acid	0.05	$/lb	3.2 mg/l = 4.5 lbs/day	$83
RO Permeate - Sodium Hypochlorite	0.79	$/lb	1.5 mg/l = 2.1 lbs/day	$600
Cartridge Filters	25	$/cartridge	7.5 per week	$10,000
RO Membrane Elements	700	$/Element	22.5 per year	$16,000
Labor	32	$/hr	8,736 hrs/year	$280,000
Maintenance	2%	of direction const. cost		$19,000
Electricity	0.1	$/kW-hr	420,000 kW-hr/year	$42,000
Residual Management				
Solids	48.15	$/ton wet sludge	8.2 g/l = 5.7 tons/day	$100,000
Liquids	0.21	$/gal	50,000 gal/day	$3,800,000
Miscellaneous				$10,000
TOTAL ANNUAL O&M				**$4,300,000**

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TABLE A3. Capital costs for treatment system size based on 2.0 MGD Reverse Osmosis permeate flow rate

ENGINEER'S COST ESTIMATE

KENNEDY/JENKS CONSULTANTS

Est By: SSH

Project: La Paloma

K/J Job No.

Date: 11-Mar-02

Task: **Capital Costs - 2.0 MGD RO Treatment System**

Type of Estimate: (X) Conceptual ( )Prelim. ( )Takeoff w/ Plans

Subdivision of Work:

Time: 10:20 AM

__Current at ENR:

__Escalated at ENR:

Item No.	Description	Quantity	Unit	Material Unit Cost	Material Extension	Labor & Equip Unit Cost	Labor & Equip Extension	Subcontract Unit Cost	Subcontract Extension	Total Cost (2002 $) Unit Cost	Total Cost (2002 $) Extension
	Heat Exchanger - Plate and Frame Type	11	EA	$6,200.00	$68,200					$6,200.00	$68,200
	10-3/4" Dia Steam Line - Insulated w/Exterior Coating	2,640	LF					$58.45	$154,308	$58.45	$154,308
	Warm Lime Softener	1	EA	$300,000.00	$300,000					$300,000.00	$300,000
	Lime Feed System	1	EA	$7,000.00	$7,000					$7,000.00	$7,000
	Cationic Polymer Feed System	1	EA	$5,000.00	$5,000					$5,000.00	$5,000
	Equalization Tank (7,000 gal FRP)	1	EA	$7,000.00	$7,000					$7,000.00	$7,000
	Discharge Pump - 100 hp	4	EA	$32,000.00	$128,000					$32,000.00	$128,000
	Pressure Filter - 8' dia; 75 psi rating	8	EA	$25,000.00	$200,000					$25,000.00	$200,000
	Backwash Pump - centrifugal	2	EA	$2,000.00	$4,000					$2,000.00	$4,000
	Reverse Osmosis (RO) System + Cartridge Filters	1	EA	$1,500,000.00	$1,500,000					$1,500,000.00	$1,500,000
	Anti-Scalant Feed System	1	EA	$5,000.00	$5,000					$5,000.00	$5,000
	Acid Feed System	1	EA	$5,000.00	$5,000					$5,000.00	$5,000
	Sodium Hypochlorite Feed System	1	EA	$7,000.00	$7,000					$7,000.00	$7,000
	Backwash Decant Tank (15,000 gal FRP)	4	EA	$15,000.00	$60,000					$15,000.00	$60,000
	Backwash Solids Transfer Pumps - progressive cavity	2	EA	$5,000.00	$10,000					$5,000.00	$10,000
	Decant Water Transfer Pumps - centrifugal	2	EA	$2,000.00	$4,000					$2,000.00	$4,000
	Belt Filter Press - 2 meter belt	1	EA	$192,000.00	$192,000					$192,000.00	$192,000
	Filter Press Water Transfer Pump - centrifugal	2	EA	$2,000.00	$4,000					$2,000.00	$4,000
	Booster Pump - 100 hp	3	EA	$32,000.00	$96,000					$32,000.00	$96,000
	Pipe (10-inch Sch 80 CPVC)	2,000	LF	$188.90	$377,800					$188.90	$377,800

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ENGINEER'S COST ESTIMATE

KENNEDY/JENKS CONSULTANTS

Est By: SSH   Project: La Paloma   K/J Job No.   Date: 11-Mar-02

Task: **Capital Costs - 2.0 MGD RO Treatment System**   Subdivision of Work: Time: 10:20 AM

Type of Estimate: (X) Conceptual ( )Prelim. ( )Takeoff w/ Plans   __Current at ENR: __Escalated at ENR:

	Fittings and Valves (20% of pipe cost)	1	EA	$75,560.00	$75,560					$75,560.00	$75,560
	Concentrator for RO Reject	1	EA	$8,600,000.00	$8,600,000					$8,600,000.00	$8,600,000
1	Subtotal of Itemized Costs				$11,700,000		$0		$150,000		$11,900,000
2	Other Direct Construction Costs										
	Site Preparation (Site Clearing, Subsurface Preparation, etc.)	10.0%			$1,200,000		$0		$0		
	Site Development (Fencing, Paving, Landscaping, etc.)	10.0%			$1,200,000		$0		$0		
	Electrical and Instrumentation	15.0%			$1,800,000		$0		$0		
3	Direct Construction Subtotal				$15,900,000		$0		$150,000		$16,100,000
4	Contractor Markups										
	Mobilization and Bonding	2.0%			$320,000		$0		0		
	Contractor's Overhead and Profit (O&P)	12.0%			$1,900,000		$0		$18,000		
	Contingencies	10.0%			$1,600,000		$0		$15,000		
5	Total Construction Cost Estimate (Bid Cost)				$19,700,000		$0		$180,000		$19,900,000
6	Indirect Capital Cost Estimate (% of Bid Cost)	38.0%			$7,500,000		$0		$0		$7,500,000
7	**TOTAL CAPITAL COST ESTIMATE**										**$27,400,000**

Note: All Line Items Rounded to Two Significant Figures or Nearest $100,000

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TABLE A4. O&M costs for treatment system size based on 2.0 MGD Reverse Osmosis permeate flow rate

O&M	Quantity	Unit	Consumption Rate	Annual Total
System Flow Rates				
Raw Water	1984.1	gpm		
RO Permeate	1388.9	gpm		
RO Reject	595.2	gpm		
Consumables				
Chemicals				
DensaDeg Feed - Lime	0.11	$/lb	756.3 mg/l = 18,036 lbs/day	$730,000
DensaDeg Feed - Polymer	2.66	$/lb	3.5 ppm = 91.7 lbs/day	$89,000
Reverse Osmosis (RO) Feed - Antiscalant	1.50	$/lb	5 mg/l = 119.2 lbs/day	$65,000
RO Permeate - Acid	0.05	$/lb	3.2 mg/l = 76.3 lbs/day	$1,400
RO Permeate - Sodium Hypochlorite	0.79	$/lb	1.5 mg/l = 35.8 lbs/day	$10,000
Cartridge Filters	25	$/cartridge	87.5 per week	$114,000
RO Membrane Elements	700	$/Element	243 per year	$170,000
Labor	32	$/hr	8,736 hrs/year	$280,000
Maintenance	2%	of direction const. cost		$19,000
Electricity	0.1	$/kW-hr	33,900,000 kW-hr/year	$3,400,000
Residual Management				
Solids	48.15	$/ton wet sludge	8.2 g/l = 97.6 tons/day	$1,700,000
Liquids	0.21	$/gal	50,000 gal/day	$3,800,000
Miscellaneous				$20,000
TOTAL ANNUAL O&M				$10,400,000